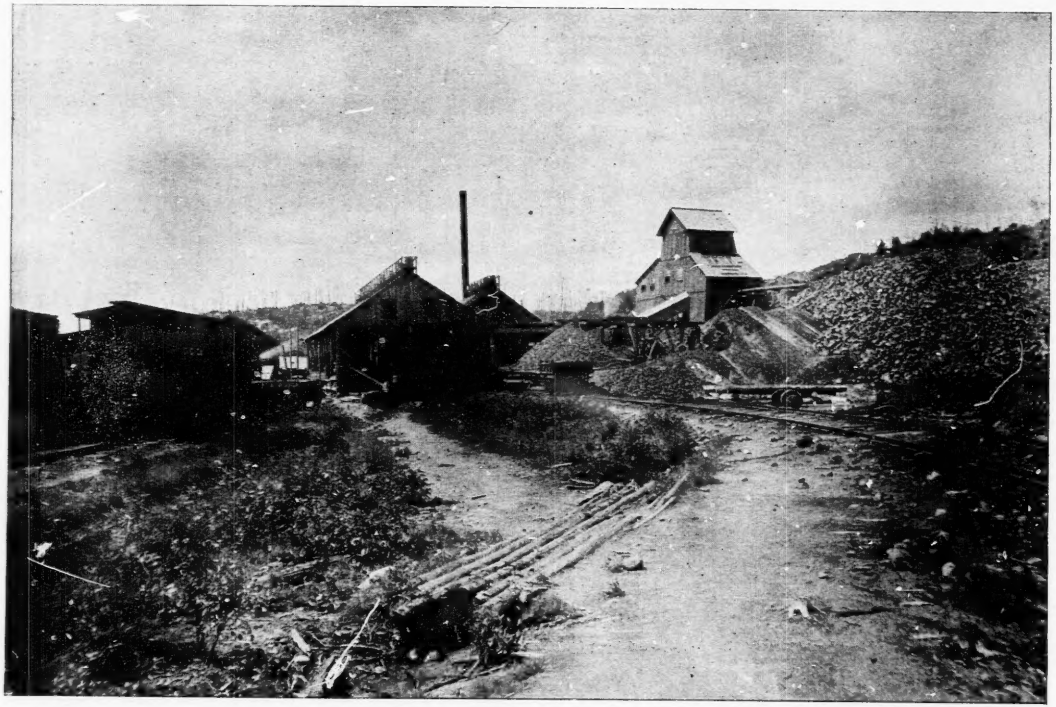

H. TOPLEY PHOTO.

DESBARATS & CIE, GRAV. ET IMP., MONTREAL.

MINE "COPPER-CLIFF," VUE DE L'EST.

GEOLOGICAL SURVEY DEPARTMENT.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

SUDBURY MINING DISTRICT

To accompany Sheet 130, Series of Geologically coloured Maps of Ontario.

BY ROBERT BELL, B.A.Sc., M.D., LL.D.

1888-90.

OTTAWA:
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S
MOST EXCELLENT MAJESTY.

1891.

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To Dr. A. R. C. Selwyn, C.M.G., F.R.S., Etc.

Sir,—Herewith I beg to hand you my report on the results of the geological and topographical surveys and investigations in the Sudbury mining district, during the past three seasons, with which I had the honour of being entrusted.

I have the honour to be, Sir,

Your obedient servant,

ROBERT BELL

Geological Survey Office,

Ottawa, 20th March, 1891.

REPORT

ON THE

SUDBURY MINING DISTRICT,

BY ROBERT BELL, B.A.Sc., M.D., LL.D.

INTRODUCTION.

The following report is upon the labours of the last three seasons in what may, for convenience, be called the Sudbury mining district. An epitome of what has been accomplished has already been given in the three summary reports of 1888 to 1890, but all the results will now be collated in a more complete form.

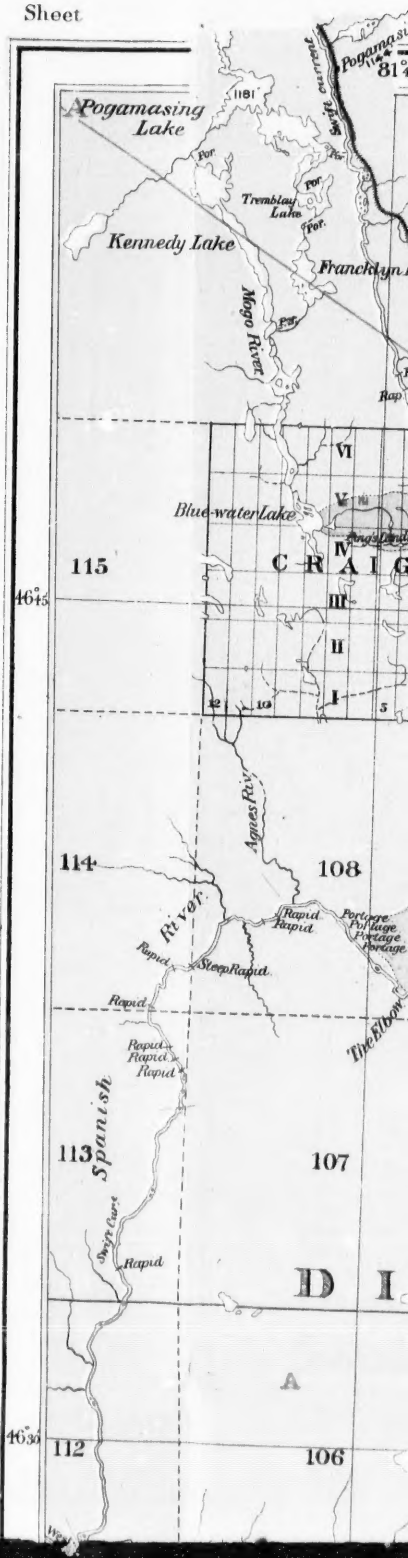
Assistants.

I was assisted in both the topographical and geological work by Mr. A. E. Barlow, M.A., of this department. He was occupied more especially in the south-eastern and central parts of the sheet. His topographical surveys are mentioned more particularly further on, and an account of his geological observations is given along with my own. Mr. A. M. Campbell, of Perth, also assisted us during the three seasons this work was in progress. Mr. Wm. Skynner was engaged upon it for portions of 1888 and 1889, and in 1890 we had the services of three young gentlemen as students, namely: Mr. T. L. Walker, M.A., Mr. H. H. Walker, B.A.Sc., and Mr. H. G. Skill. To all of these gentlemen great credit is due for enthusiasm and patient endurance of the hardships and discomforts incidental to this kind of work.

Acknowledgment of aid.

We are indebted for assistance or information in the prosecution of our labours to Mr. D. McTavish and Mr. T. B. Ross, of the Hudson's Bay Company; to Dr. E. D. Peters, ex-manager of the Canadian Copper Company; Messrs. O. Emery and D. McLaren, of Wahnapitæ; T. J. Kennedy, C.E., of Pogamasing; T. Frood, of Wallace Mine; J. Stobie and C. W. Jessop, of Sudbury: J. R. Gordon, of Creighton; F. L. Sperry, late chemist to the Canadian Copper Company; F. R. W. Daw, manager of the Murray Mine; J. Ferguson, manager of the Dominion Mine; A. Merry; W. Cockburn, of Sturgeon Falls; A. McCharles, of Whitefish; H. Ranger, of Mattawa, and others.

Sheet



Explanation of Colours.

Cambrian ?.

C — *Dark argillaceous and gritty sandstones with shaly bands possibly Lower Cambrian.*

C — *Blackish siliceous volcanic breccia with black slate in some parts.*

Huronian.

B — *Quartzites agglomerates, greywackés, felsites, stratified quartz-diorites, clay slates, various kinds of crystalline schists and rarely bands of dolomite.*

Di. Dia. — *Greenstones.*

Laurentian.

A — *On the North-west side of the Huronian belt these rocks consist of red and grey hornblende-granite and gneiss, merging into each other; on the S.E. Side are gneisses only.*

Greenstone dykes.

Dip.

Vertical strata.

Glacial striæ.

Gold.

Copper.

Nickel.

№ 129.

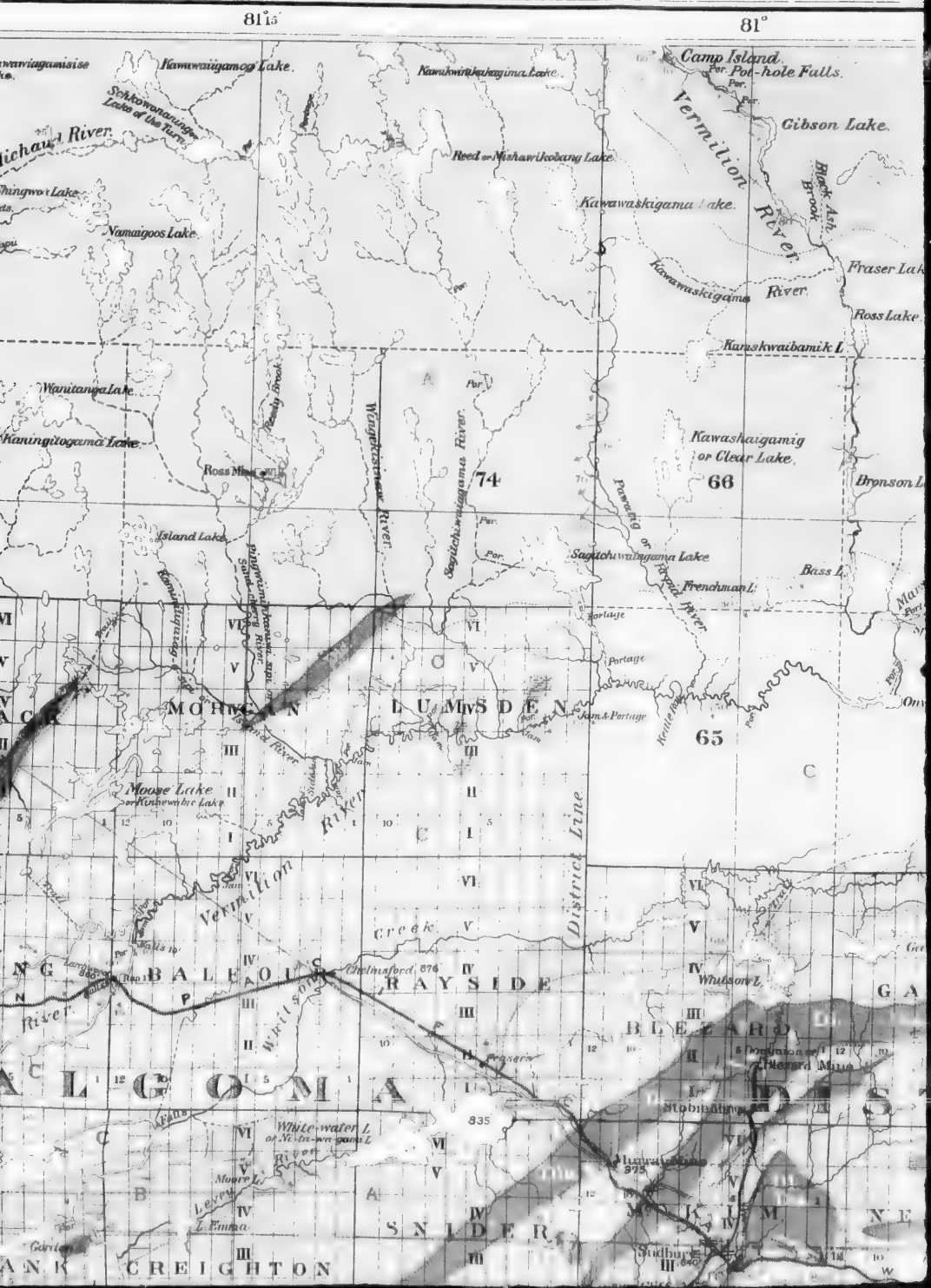
ONAPING LAKE
LOWER ONAPING LAKE
Onaping River
Pogamasing River
Mogo River
Agnes River
Kasakawawiagamisk Lake
Tremblay Lake
Franchdyn L.
Straight Lake
Blue-water Lake
Genera Lake
Bid Lake
Trout L.
Cartier
Crowduck or Trail L.
Weqved L.
Ministic L.
Lake Totten
Armstrong L.
Vermilion Lake
Windy Lake
Steep Rapid
The Elbow
Portage
Rapid
CRAIG
MONCRIEFF
HESS
HART
CARTIER
LEVACK
DOWLING
ERMATINGER
CASCADEN
TOTTEN
TRILL
FAIRBANK
DISTRICT OF
87
108
107
106

Geological Survey Department, Canada.

HONOURABLE EDGAR DEWDNEY, MINISTER

ALFRED R.C. SELWYN, C.M.G., LL.D., F.R.S., &c., DIRECTOR

1891.



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HONOURABLE EDGA

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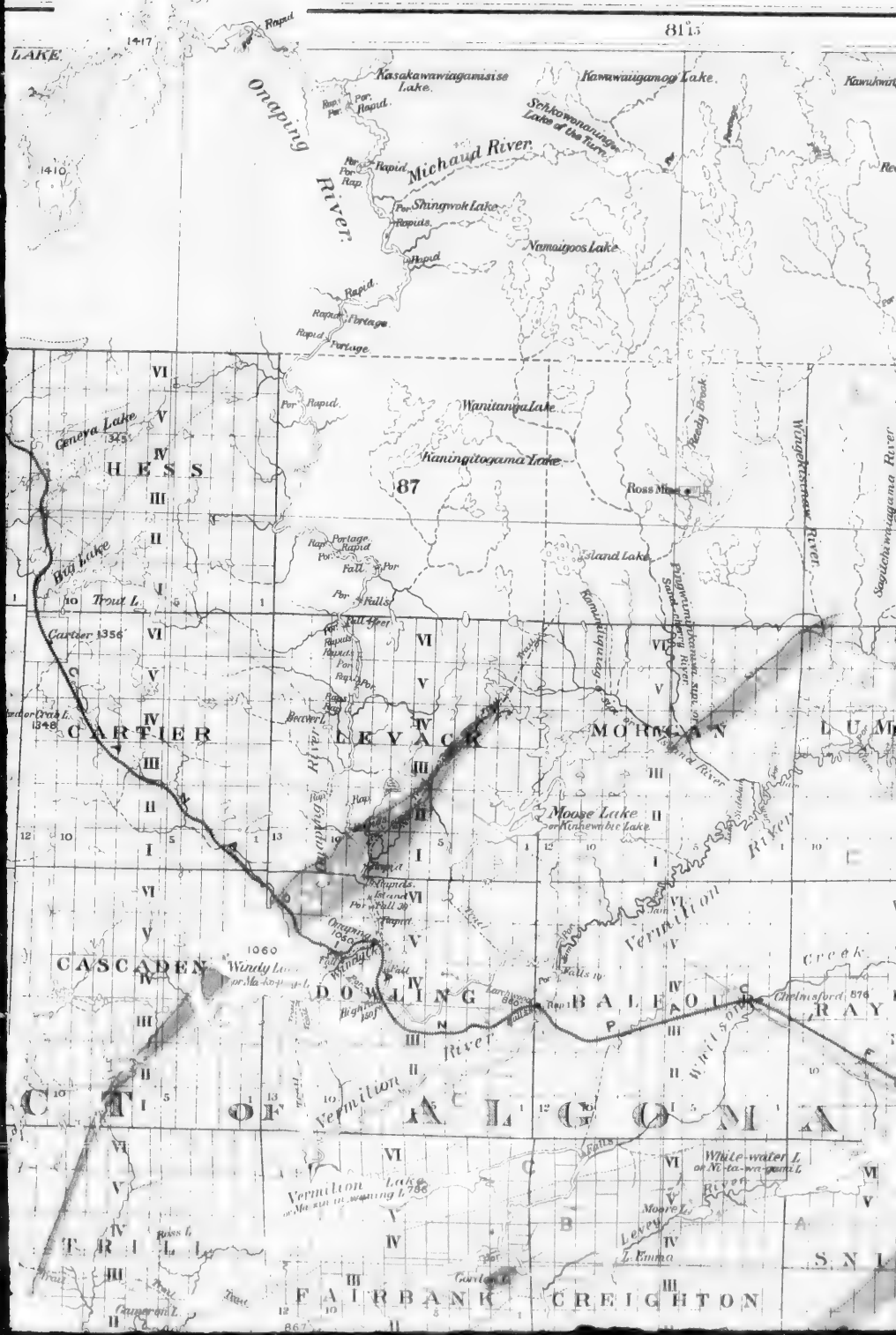

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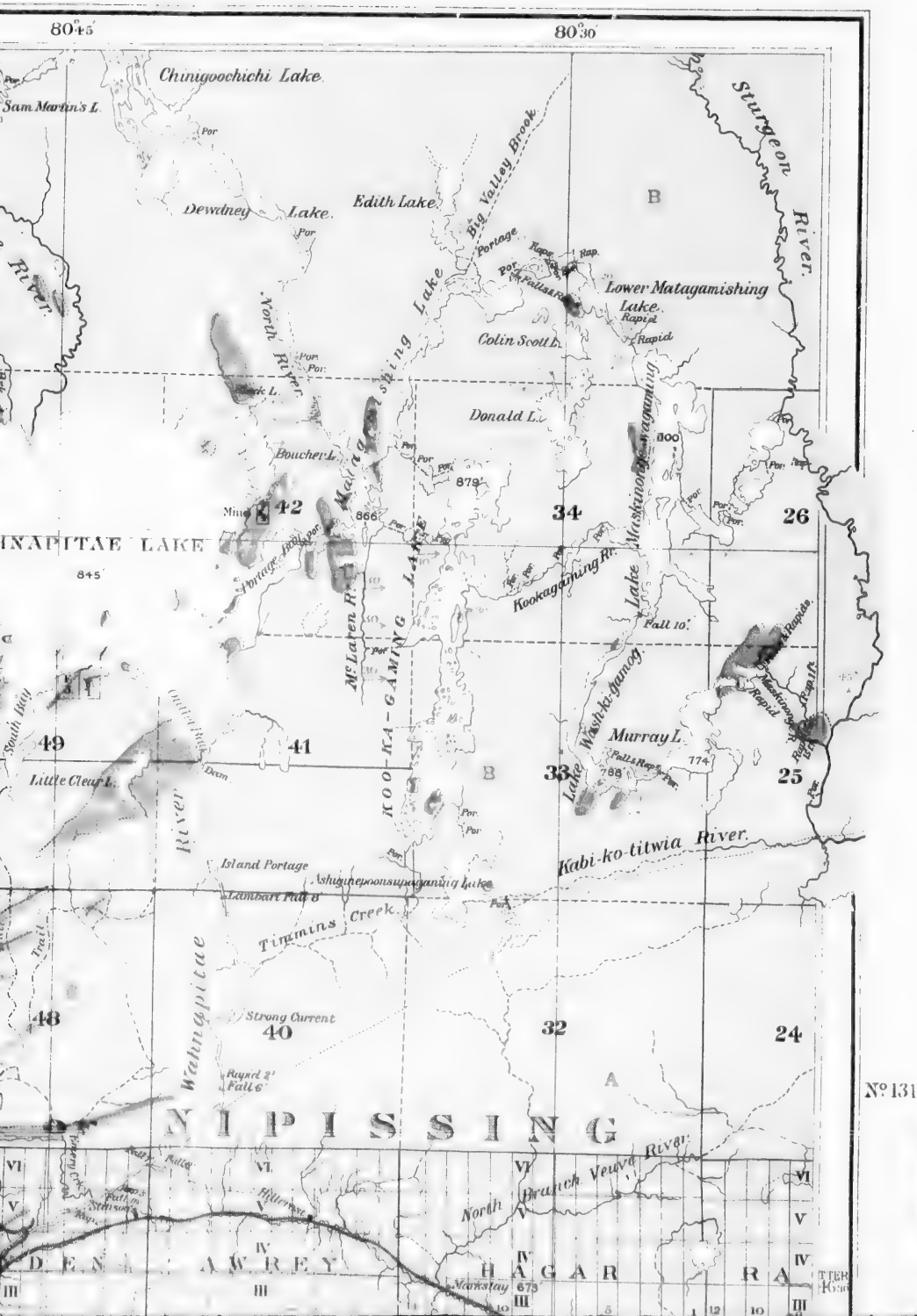

80°45'
80°30'
Chinigoochichi Lake.
Sam Martin's L.
Dewdney Lake.
Edith Lake.
Big Valley Brook.
Portage.
Sturgeon River.
Lower Matagamishing Lake.
Rapid
Colin Scott L.
North River.
Donald L.
Boucher L.
Marg Lake.
Mattagamishing Lake.
Maskinonge-wagaming
Mine
42
34
26
INAPITAE LAKE
845
Portage
McLaren R.
KOO-KA-GAMING LAKE
Kookagaming R.
Lake Washki-ganog.
Fall 10'
Rapids
Murray L.
Falls
Rapid
49
41
33
25
Little Clear L.
South Bay
Island Portage
Ishquinepoonsuppagaming Lake
Kabi-ko-titwia River.
Lambart Falls
Tingimins Creek.
Trail
Wahnapitae River
48
40
32
24
Strong Current
Rapid 2'
Fall 6'
A
NIPISSING
Nº 131
North Branch Veuve River.
DENAWREY
HAGAR
RATTER
Markstay
673

Vertical strata

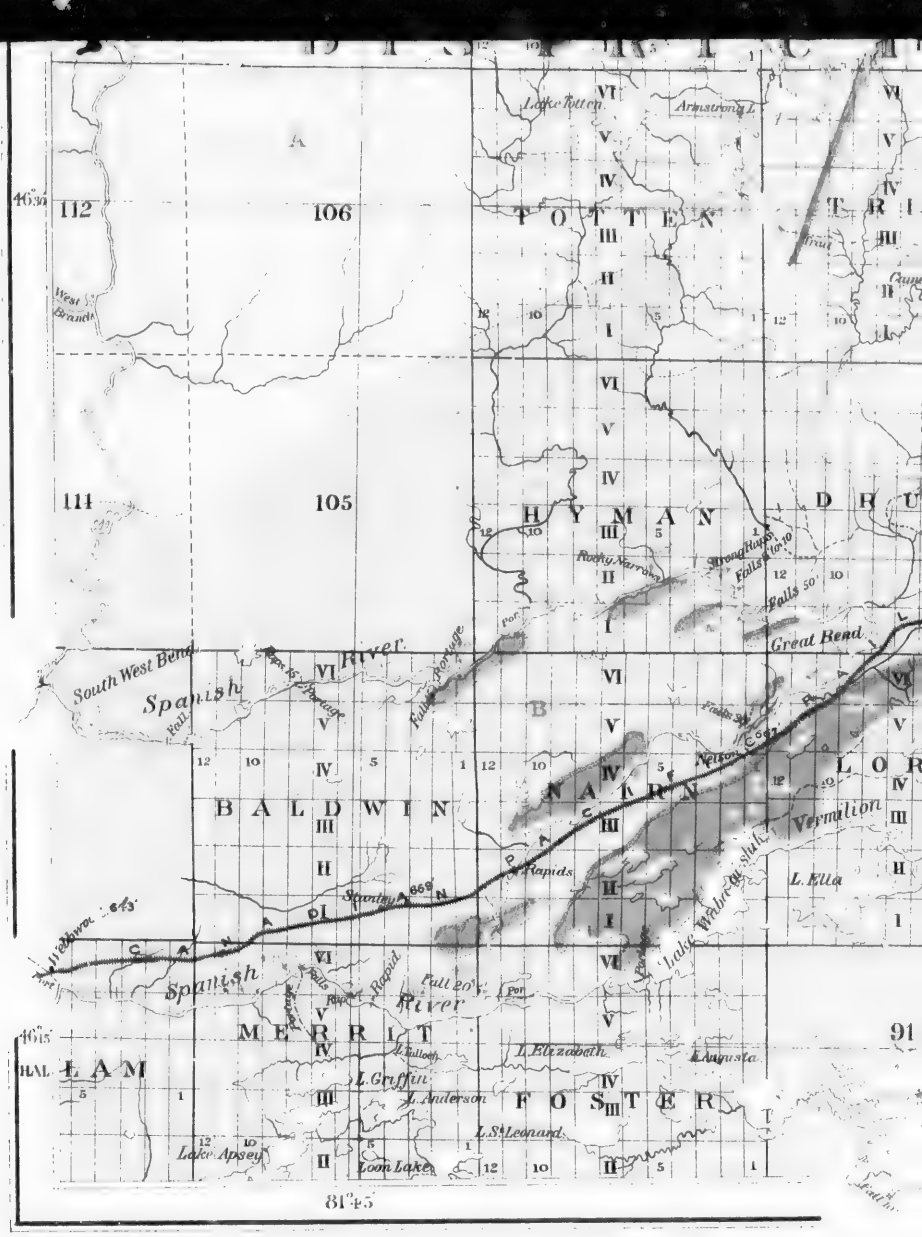
Glacial striæ.

Gold

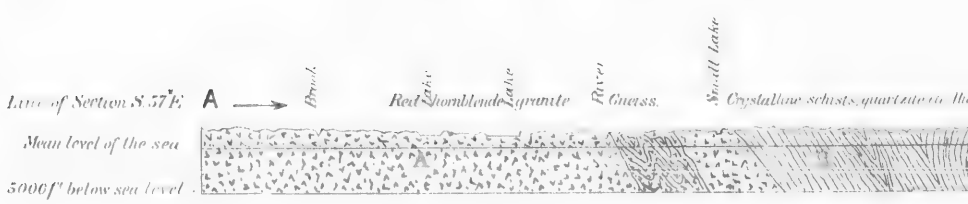
Copper

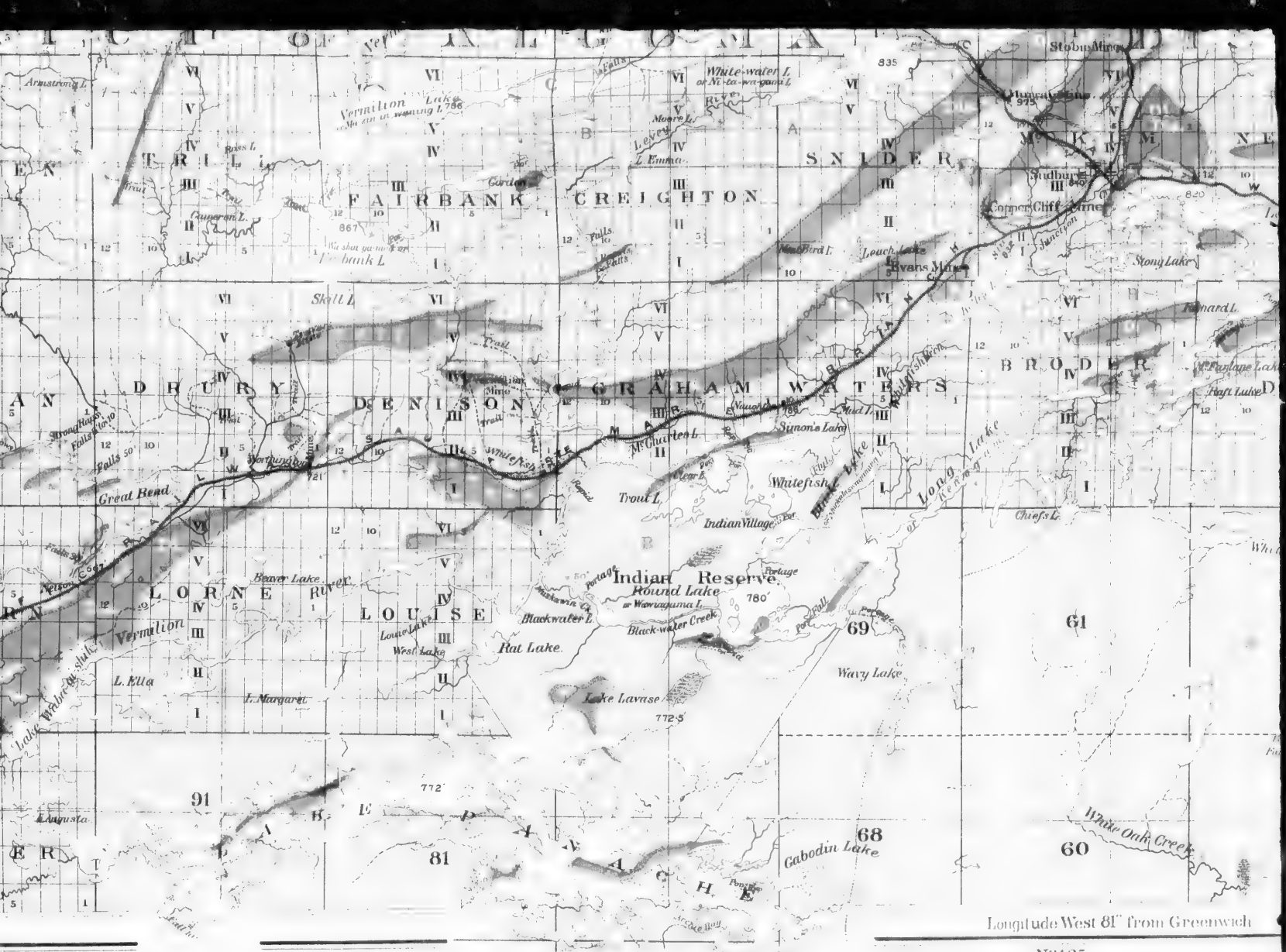
Nickel

Heights in feet above sea level are marked thus 38.4 Those of the Lakes are partly from Government road maps while those along the lines of railway are from C.P.Railway profiles



Compiled and Drawn by S.Barlow, Chief Draughtsman, assisted by A.E.Barlow, M.A. and L.N.Richard, B.App.Sc. from Sur R.Bell, M.D., L.L.D. Assistant Director; and A.E.Barlow, M.A. 1889-90 Crown Lands Department and Canadian Pacific Railway





A. and L. N. Richard, B. App Sc. from Surveys made by A. Murray, Esq. Asst Provincial Geologist, 1856,
tment and Canadian Pacific Railway

Mortimer & Co. Lith Ottawa, Ont.

No 125

PROVINCE OF ONTARIO.

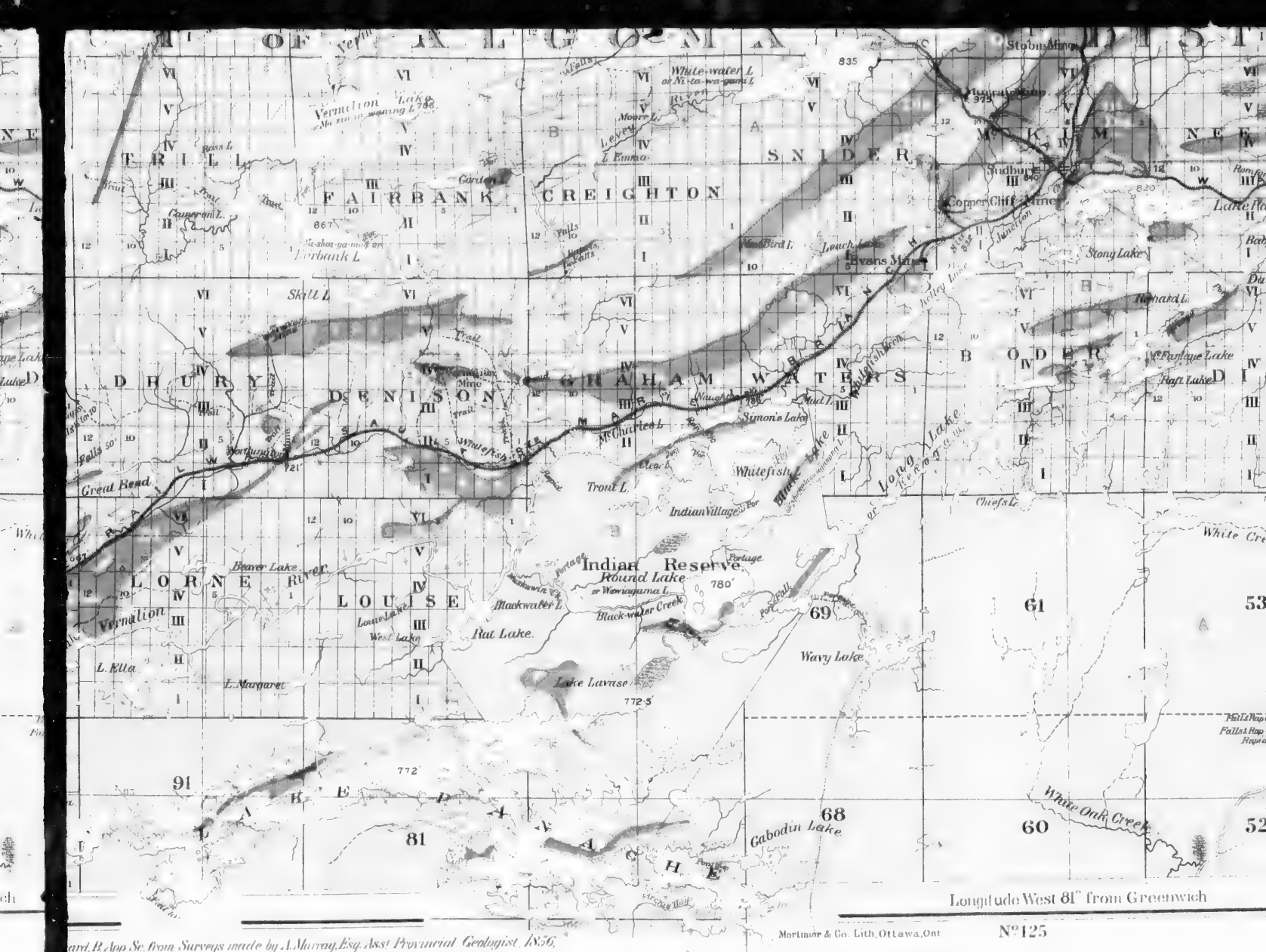
DISTRICTS OF ALGOMA AND NIPISSING.

(Sudbury Sheet.)

Nat. Scale. $\frac{1}{253\,440}$

Scale 4 miles to one inch.

1 0 5 15 Miles



Longitude West 81° from Greenwich

ard, R App Sc. from Surveys made by A. Murray, Esq. Asst Provincial Geologist. 1856.
nadian Pacific Railway

Mortimer & Co. Lith, Ottawa, Ont

No 125

PROVINCE OF ONTARIO.

DISTRICTS OF ALGOMA AND NIPISSING.

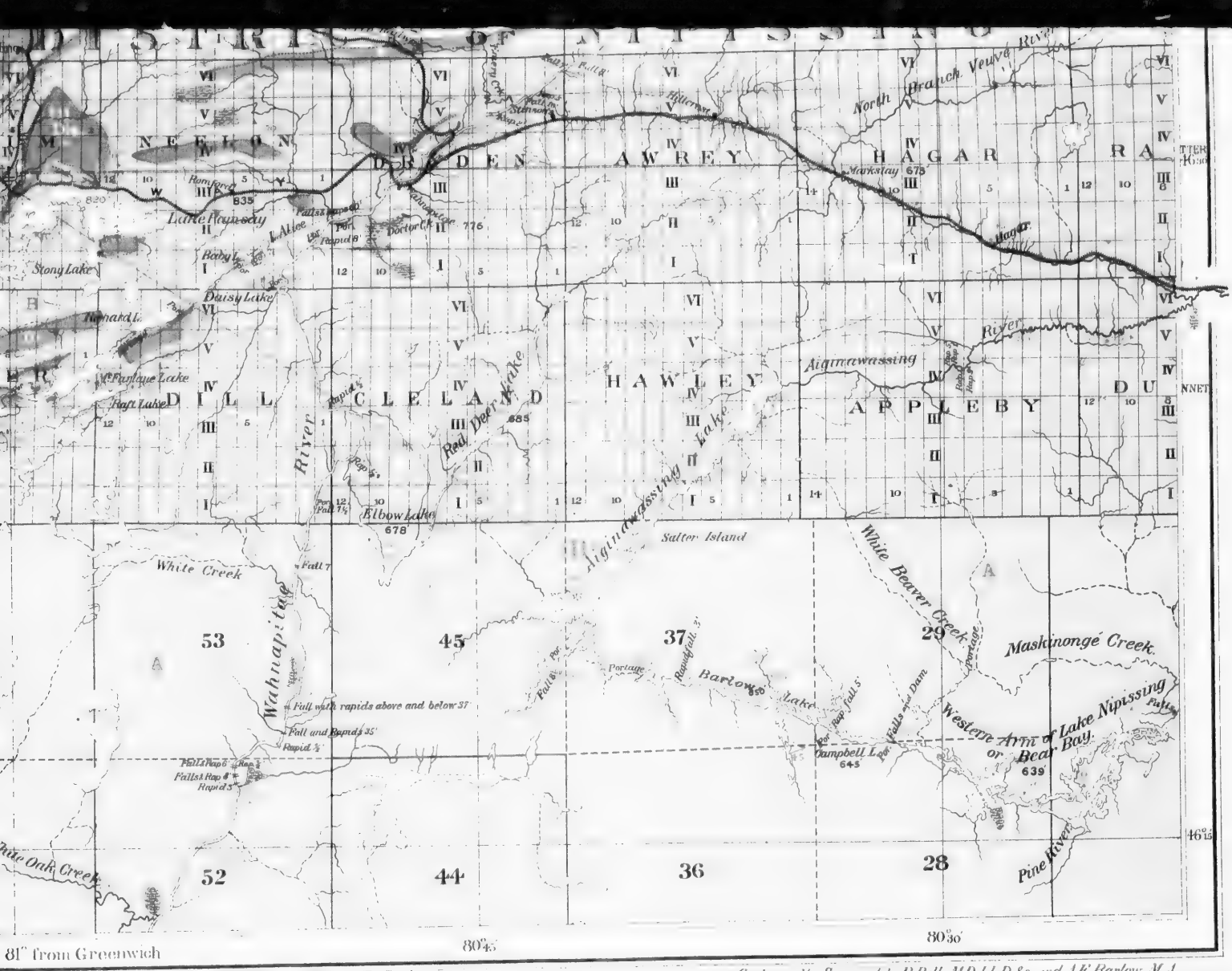
(Sudbury Sheet.)

Nat: Scale. $\frac{1}{253,440}$

Scale 4 miles to one inch.

1 0 5 10 15 Miles

schists, quartzite &c. Huronian | Hornblende granite | Hawk Brook | Granite | Big Lake. | Trout Lake. | Red Brook. | Hornblende Granite | Brook | Brook | Brook | Ongaing River. | Brook | Lake | Brook. | Grey Gabbase | Moose Lake. | Dark volcanic breccia. | Brook. | Vermilion R | Sandstones. | Brook | C.P.R. | Whitson Creek | Black slates | Brook | Greywacke, crust schist &c | Whitewater L. | Gneiss


North Branch Veuve River
Lake Ramsay
Stony Lake
Daisy Lake
Tennant L.
McFarlane Lake
Raft Lake
Baby L.
Lake Alice
Rapid 8
Doctor Lk
Rapid 6
Rapid 5
Rapid 4
Rapid 3
Rapid 2
Rapid 1
Red Deer Lake
Elbow Lake
678
Aigamawassing Lake
Aigamawassing River
Salter Island
White Creek
Fall 7
Wahnapitae River
Fall with rapids above and below 37
Fall and Rapid 35
Rapid ½
Falls Rap 6
Falls Rap 4
Rapid 3
Portage
Rapid fall 3
Barlow Lake
650
Fall 6
White Beaver Creek
Portage
Maskinongé Creek
Falls and Dam
Rap falls 5
Campbell L.
643
Westerne Arm of Lake Nipissing
or Bear Bay.
639
Pine River
Oak Creek
Markstay
675
Hagar
Rapid 8
Rapid 5
Rapid 4
Rapid 3
Rapid 2
Rapid 1
Rapid 6
Rapid 5
Rapid 4
Rapid 3
Rapid 2
Rapid 1
Rapid 8
Rapid 6
Rapid 5
Rapid 4
Rapid 3
Rapid 2
Rapid 1
Rapid 7

Prof. Williams' description of the rocks.

Professor George H. Williams, of Johns Hopkins University, has made for us a painstaking microscopical examination of a collection of rock-specimens from the district, and his descriptions, which will be again referred to, form Appendix I of this report. Professor T. G. Bonney, of London, has also kindly supplied me with some petrographical notes on the district.

Prof. T. G. Bonney.

List of levels.

Appendix II consists of a list compiled by Mr. Barlow, showing the levels, above the sea, at every mile on the main line and also on the Sault Ste. Marie branch of the Canadian Pacific Railway, which come within the limits of the sheet, and of the principal streams at their intersections by the railway line; also of the levels of the larger lakes as determined by the barometer.

List of Lepidoptera by Major H. H. Lyman.

Our thanks are once more due to Major H. H. Lyman, of Montreal, who has this winter gratuitously determined a collection of Lepidoptera which I had made in the country north of Lake Huron. He finds it to contain fifty-four (54) species, represented by a considerable number of specimens from many localities in the above district. Major Lymam was assisted by Mr. Wm. H. Edwards, Professor J. B. Smith and Rev. Geo. D. Hulst. The list of species forms Appendix III of this report.

Map.

A map has been compiled and drawn by Messrs. Scott Barlow, A. E. Barlow and L. N. Richard on a scale of two miles to the inch, and reduced under the supervision of Mr. Scott Barlow, for publication, on a scale of four miles to the inch, showing the topography and geology of the area investigated. As the geological and most of the topographical features of the district have been as yet unknown, this map, which will accompany the present report, will be essential for reference in connection with the descriptions herein given.

Area and position of the district.

It constitutes sheet number 130 of the general Ontario series and the district which it embraces measures seventy-two miles in length from east to west and forty-eight miles in breadth from north to south. It thus includes an area of 3,456 square miles, or 2,211,840 acres. The town of Sudbury Junction lies ten miles south-east of the centre of the above rectangle. The main line of the Canadian Pacific Railway runs north-west across the sheet, emerging near its north-west corner, not far from Pogamasing Lake, and the Sault Ste. Marie branch, running south-westward from Sudbury Junction, emerges at the south-west corner in the township of Hallam. Sturgeon River crosses the north-east corner, and the West Bay of Lake Nipissing enters the south-east corner. These geographical positions will enable the reader to form a better idea of the size and location of the above district.

Surveys heretofore made.

Nearly half the included lands, or 1,530 square miles, have been laid off into townships, which again have been subdivided into concessions

and lots. These townships are of the more recent form adopted by the Crown Lands Department of Ontario and measure six miles square, each one comprising six concessions, running east and west, and each concession twelve lots. The townships themselves are arranged like squares on a checker-board, and as their subdivisions are all alike, both the concessions and the lots carry the same numbers from one to another throughout. All the township boundaries, or town-lines, the concession lines and every second lot line, called side-lines, are cut out through the woods, and posts, marked with the numbers of the concessions and lots, are planted at the intersections of the above lines. Each lot, therefore, contains half a square mile or 320 acres. For the sake of greater clearness the numbers of the concessions are always designated by Roman numerals and those of the lots by ordinary figures, both on the map and in this report. In tracing out the rocks, we found the surveyors' lines and posts of much service in fixing our positions.

Want of facilities for geological field-work.

The railway track afforded us a means of getting into the district and a sort of basis for operations, but scarcely any common roads or even trails existed* and there are fewer canoe-routes than usual in the Laurentian and Huronian regions of Canada, so that it became necessary to examine a large portion of the area by forcing our way through the bush, which, in most of the district, is unusually difficult to traverse. In some sections the surveyors' lines made it easier to penetrate the thick woods, but as these are cut out merely for sighting, the felled trees and brush and the new growths are as apt to encumber the ground and impede one's progress as the standing forest and underbrush.

General character of the country.

The average general elevation of the district is probably between 800 and 1,000 feet above the sea.† The district, taken as a whole, may be described as hilly and rocky, although a tolerably level tract, six miles wide, extends from near Wahnapitæ Lake south-westward to Vermilion Lake. Parts of this tract are covered by a light coloured fine clayey sand, free from boulders. Some of this land along the line of the railway between Chelmsford and Onaping is being cultivated; but rocky ridges and boulder-covered slopes, alternating with swamps and small lakes, are the rule over the greater portion of the area. In most parts the boulders are not only thickly scattered over the uneven rocky surface, but are often piled on top of one another without any finer materials between them. The trees which originally grew between and even on top of the boulders have generally been killed by forest fires and their trunks have fallen over them in every direction. A second

Difficulties of exploration.

* A colonization road has lately been constructed from Sudbury for eleven miles northwest and three and a half south-west.

† A list of levels throughout the district is given as an appendix.

growth thicket of small prickly spruces entangled with tough young birches has sprung up among the boulders and resists the explorers' progress like a continuous hedge. This, together with the uncertain footing, due to the boulders and the network of prostrate trunks, renders it very difficult to make one's way through these obstructions. Indeed, it sometimes became impossible to do so until we had first chopped a passage through them. Last summer and autumn were unusually rainy, so that whenever we got clear of the boulders and hummocky rocks we were obliged to wade in the water.

Surveys.

Proudfoot's lines.

In addition to the railway and the township surveys, a straight line had been run, in 1888, by Mr. H. B. Proudfoot, P.L.S., for the Crown Lands Department, due north in continuation of the east town-line of Lumsden, to a point four miles and a-half north of the northern boundary of our sheet, and from this point another straight line was run by the same gentleman due west to beyond Lake Pogamasing. Although this latter line was outside of the area with which we were more immediately concerned, still it was of service for tying on our exploratory and micrometer surveys.

Murray's surveys.

Topographical surveys had also been made by the late Mr. Alexander Murray, of the Geological Survey, of Wahnapitæ River and Lake and Sturgeon River, Lake Panache and the canoë-route thence to Wahnapitæ Lake; also of the curving chain of lakes from the latter to Sturgeon River. Mr. Murray had also surveyed the Spanish River from the mouth to a point a few miles above the Great Bend, but this survey had been covered by the township surveys in that quarter. Many topographical features still remained unsurveyed within the area of the present sheet, and these have now been surveyed and located by Mr. Barlow and myself.

Surveys by Bell and Barlow.

Mr. Barlow's topographical work was mainly in the south-eastern part of the sheet, and comprised the West Bay of Lake Nipissing (a re-survey), Panache Lake (a re-survey), the southern branch of Veuve River, Aigin-a-wassing, Elbow and Red Deer Lakes, two western branches of Wahnapitæ River, Ramsay Lake (a re-survey), Vermilion River from Larchwood for eighteen miles upward, in a straight line, and a number of smaller lakes. My own instrumental surveys embraced the Spanish River, from near Spanish Forks to the township of Hyman, Pogamasing Lake, the west shore of Wahnapitæ Lake (a re-survey), the route thence to Vermilion River, and the latter river from the point reached by Mr. Barlow, as far as Proudfoot's east and west line. I also made track-surveys of the route from Bannerman Lake to Onaping Lake, of the latter lake (thirty miles long), Onaping River, the Upper Wahnapitæ

River, Koo-ka-gaming Lake and a number of smal er lakes and rivers. In 1875, while exploring this part of the country geologically, I had improved upon a track-survey of the chain of lakes from Lake Wahnapitæ northward by way of Lakes Mattagamashing and Chini-goo-nichi, and in 1888 I carried my track-surveys north-eastward to the Montreal River. In addition to the foregoing, explorations were made of numerous smaller lakes and streams within the sheet. Some of these were performed by the other assistants or students who have been named, and an exploration of the chain of lakes southward of Pogamasing Lake was made by the late Mr. W. E. Francklyn, who was a member of my party in 1889.

Explanations.

In the topographical and geological descriptions which follow, all distances are understood to be given in straight lines and all bearings refer to the magnetic meridian, unless otherwise stated. The average variation in the district, as stated on the township plans, is about 6° W. in the eastern part of the sheet and 3° W. in the western part. In our geological examinations along the railway tracks, the positions were fixed by the mile-boards, which, on the main line, are numbered from Montreal and on the Sault Ste. Marie branch from Sudbury Junction.

Geographical names.

All existing geographical names were adopted for the map and this report. In some cases the expressive Indian names which had been in use from time immemorial had been replaced by others on the surveyors' township plans. In such instances, while accepting the latter, we have also restored the aboriginal designations upon our map. But it was found that many features made known by our explorations and surveys, to which frequent reference required to be made, had no names whatever, and to these, for convenience of reference, we were obliged to give some distinguishing appellation.

Geology.

In connection with the geological descriptions, passing references will be made to the surface geology and the occurrence of ores or other economic minerals, but the principal part of the information as to these subjects will be reserved for fuller descriptions by themselves in another part of the report.

Lithological names.

Lithologically speaking, there is a great variety of rocks in the district and many of them are of much interest in connection with a study of the problems of metamorphism, etc. A collection of fifty specimens above referred to, mostly from within the district, was submitted for microscopical examination to Professor George H. Williams, of Johns Hopkins University, the well known lithologist. A few specimens, however, were included in this collection from places outside of the district on account of their bearing on its geology, and it was thought that a study of them would be of advantage in this connection. We

Prof. G. H. Williams' report.

are indebted to Professor Williams for the great pains he bestowed on this task. His report forms Appendix I. Mr. Walter Ferrier of this Survey has examined microscopically some thin slices of rocks from the Sudbury district and has given us the benefit of his studies.

Field names for rocks.

In the field, however, it is impossible to make the precise distinctions which may be established by subsequent microscopical study. The most appropriate field names have, therefore, to be adopted, and in the present report these are often adhered to for brevity of description. For example, it is frequently difficult to distinguish between such rocks as diorites, diabases, basalts, gabbros, etc., nor, indeed, is it always of practical importance to do so. But when we were tolerably certain, from the macroscopic characters, of the variety we were dealing with, we called it, in our notes, by its proper distinctive name; but where there was room for doubt, we adopted the general term greenstone. On this point Professor Williams, in his report on The Greenstone-Schist Areas of the Menominee and Marquette Regions of Michigan,* says: "I feel no especial apology is needed for the constant use throughout this paper of the term 'greenstone.' An opinion prevails that this word is antiquated and not consistent with the scientific accuracy now obtainable. The very indefiniteness of this designation, however, constitutes its chief value. It is essentially a field term, and as it is not only desirable, but absolutely necessary to employ. It is often impossible to state with certainty in the field whether a given basic massive rock is a gabbro, a diabase or a diorite; indeed, where such masses have undergone extensive metamorphism, as in the regions here studied, even the most careful microscopical and chemical investigation may prove inadequate to disclose what was the original form."

Similarly it is impossible to give at sight the refined lithological name for every variety of rock of the granitoid class, but the best term for all practical purposes had to be adopted in each case in the field. Granitoid rocks, consisting of quartz, orthoclase, plagioclase, hornblende or chlorite and sometimes a little mica, together with a variety of accessory minerals, were among the commonest we had to deal with. The quartz was generally one of the most abundant constituents, and the rock would then be called a granite, but sometimes it was in small quantity, or it might be scarcely apparent without the aid of the microscope, when it was termed syenite, or if fine grained micropegmatite. Again, the term greywacke may be applied to certain varieties of arkose, argillaceous or felspathic sandstone, volcanic mud or ash, granitic debris, etc. It is often puzzling to discriminate between the numerous varieties of green schists and other crystalline rocks, so

* Bulletin of the United States' Geological Survey, No. 62, 1890.

that in the field, hard and fast lines cannot be drawn in reference to names for many of the rocks which we had to deal with in this district,

The term "massive" was employed in our field-books and it will also be used in this report, not only in connection with crystalline rocks, such as greenstone and granite, but also in regard to any solid or heavily bedded rock in which the stratification was faint or which showed neither cleavage nor lines of division along the bedding. Massive rocks

The rocks of the district represented by the map may, for the present, be divided into three groups, in the following ascending order: (1.) A gneiss and hornblende-granite series—Laurentian. (2.) A series comprising quartzites, massive greywackes, often holding rounded and angular fragments, slaty greywackes with and without included fragments, drab and dark grey argillites and clay-slates, dioritic, hornblendic, sericitic, felsitic, micaceous and other schists, and occasionally dolomites, together with large included masses or areas of pyritiferous greenstones. This group constitutes the ordinary Huronian of the district. (3.) A division consisting of a thick band of dark-coloured silicious volcanic breccia and black slate (generally coarse), overlaid by drab and dark grey argillaceous and nearly black gritty sandstones and shaly bands. The breccia is underlaid in places by quartzite conglomerate. (4.) In addition to these, dykes of diabase and gabbro cut through all the foregoing and are therefore newer than any of them, although they may not belong to a later geological period. The geographical distribution of these different divisions, their characters, their relations to each other and various facts in regard to them will be given further on. Divisions of the rocks.

The rectangle covered by the sheet is traversed from south-west to north-east by a belt of Huronian rocks of the above character (2), flanked on the south-east side by gneiss, and on the north-west by a mixture of gneiss and hornblende-granite. The gneiss of the south-east corner of the sheet is of the characteristic Laurentian type, and in the northern and north-western parts there is a good deal of similar rock, but associated with it and bordering the Huronian belt on its north-west side, there is a large development of reddish hornblende-granite and quartz-syenite, which are not always characteristic of the Laurentian system. But these rocks pass into the gneisses and are so mingled with them on both a large and small scale that it becomes impossible to make a separation, and we have been obliged to indicate them all by one colour on the map. Distribution of the rocks.

In the central part of the sheet there is a distinct basin of less altered rocks, being the third division in the above classification, which runs from the township of Trill north-eastward near the South Bay of Lake Wahnapitæ, a distance of thirty-six miles with a breadth of A distinct geological basin.

eight miles in its central portion. These are, perhaps, unconformable to the older Huronian rocks on which they rest, and may be upper Huronian or possibly lower Cambrian. As will be seen by the map, this well-defined basin constitutes an important feature in the geology of the district.

A tongue of gneiss and granite.

To the south-east of it, or in the middle of the belt of older Huronian rocks, a tongue of gneiss and hornblende-granite runs parallel with this trough, a slightly greater distance each way, or a total length of thirty-nine miles, with a breadth of two to three miles. For the greater part of this distance it is separated from the newer basin by a belt of quartzites, greywackes, felsitic and hornblendic schists. It is joined by a narrow neck, in the township of Trill, to the great body of hornblende-granite to the north-west. On the south-east side of this tongue, and almost separated from it by a band of diabase, is a second and parallel belt of similar gneiss and hornblende-granite extending from the township of Denison into Blezard, a distance of eighteen miles, with a breadth of a mile and a-half. As a rule, the gneisses and hornblende-granites of both these belts are finer grained or less thoroughly crystalline and more darkly coloured than those of the great area lying to the north-west of them. In addition to these two almost detached belts of gneissic and granitic rocks, there is a small isolated inlier of red hornblende-granite on the west side of Outlet Bay, Lake Wahnapitæ, and one of gneiss in the fourth concession of Denison.

A second belt of gneiss and granite.

Part of the great Huronian belt.

Our second or Huronian division of this district forms part of the great belt of these rocks extending from Lakes Superior and Huron nearly to Lake Mistassini. In the central part of the sheet it is very much contracted, being only from ten to twelve miles wide, including the two inlying belts of gneiss and hornblende-granite, but its geographical breadth increases rapidly both to the south-west and north-east. Its north-west boundary or line of contact with the great hornblende-granite area to the northward, in going north-east, crosses Spanish River in the south-western part of the sheet, four miles above the great south-western bend of this stream in the township of Shakespeare, and after throwing off, in the township of Trill, the long tongue already described it continues north-eastward to the west shore of Lake Wahnapitæ, having the basin of newer rocks (3) on its south-eastern side nearly the whole way. From the west side of Lake Wahnapitæ, the boundary turns north-west, crosses the Vermilion River and then both of Proudfoot's lines a short distance west of their point of intersection. The Laurentian area thus forms a promontory, the eastern extremity of which touches Lake Wahnapitæ. Southward of this are the eastern extremities of the basin of newer rocks and the Laurentian tongue just

Its N.-W. boundary.

referred to. Around these three, as a whole, the rocks of the second division sweep with eastward curves, in an anticlinal form, which become more and more divergent and the strata more nearly horizontal as we approach Sturgeon River at the eastern limit of the sheet. It will be seen by the map that the principal topographical features in this section, including Sturgeon River itself, all curve parallel with the trend of the rocks. Strata run in sweeping curves.

Quartzites are the predominating rocks in the Huronian belt from the south-west corner of the sheet eastward to the township of Broder, but they are interstratified with a considerable proportion of greywacke and include a number of the greenstone areas. Around Lake Panache they are associated with dolomites and in the township of Denison with schists, gneiss, diorite, breccia, agglomerate, etc., which will be described further on. Between Lake Panache and the shore of Lake Huron and thence westward to the mouth of Spanish River, including the La Cloche Mountains, the quartzites are very largely developed. The bedding is either nearly vertical or stands at high angles. The more massive or durable wide bands form high east and west ridges, on the steep slopes of which the exposures of white marble-like rock form a striking contrast to the dark green of the coniferous trees. The straight intervening valleys are occupied by lakes, swamps or marshes and streams. The highest parts of the La Cloche Mountains rise to elevations above Lake Huron varying from 755 feet north of Great Cloche Island to 1,180 feet at eight miles north of Collins Inlet. The great quartzite belts which form these mountains appear to double round in the space between Lake Panache and Lake Huron and to be repeated in the high ridges forming the backbones of the long points which jut out south-westward towards Manitowaning Bay. Lake Panache discharges into Lake Huron through a series of narrow east and west lakes lying at successively lower levels and supplied by the short rapid streams or waterfalls that break, at right angles, through the lowest gaps in the quartzite ridges which hold up the water of each one above the level of the next below, the whole chain being called Whitefish River. Quartzites predominate. La Cloche mountains. Lake Panache to Lake Huron.

Impure magnesian limestones are found at several places along the northern side of Lake Panache. They are generally fine grained and semi-crystalline, of light greyish colours and always contain a large proportion of silica, in the form of grains and threads or strings. The purer of two specimens from the north shore of this lake, analyzed by Dr. T. S. Hunt, gave 55·10 per cent. of carbonate of lime and 6·5 per cent. of carbonate of magnesia, the balance being insoluble matter. The exposures of limestone on this lake do not all appear to belong to one band; indeed, they may constitute a number of great masses wholly or partly formed by a process of segregation or concretion and Magnesian limestones.

may be unconnected with each other. At one part of the shore, where the limestone is well exposed, Mr. Murray estimated its thickness to be 150 feet. A band of impure light greenish grey dolomite, weathering brown, crosses the Wahnapitæ River at Island Portage, about three miles below the outlet of the lake. The rocks are here nearly vertical, but undulate a good deal, and I estimated this band to have a thickness of at least 300 feet.* The rocks around Lake Panache and thence by the canoe-route to Lake Wahnapitæ are described by Mr. Murray in the Geological Survey Report for 1853-56, pages 178-190.

Dolomite on Wahnapitæ River.

Contracted part of Huronian belt.

Wahnapitæ River.

In the central or contracted part of the Huronian belt the greywackes constitute a large proportion of the whole, and they include a number of areas of greenstone, ranging from a few chains up to one nearly eleven miles in length. The Wahnapitæ River, for the first nine miles below the lake of the same name, runs nearly south, crossing the Huronian rocks diagonally and it then meets the Laurentian gneiss and is deflected south-west for eight miles along the boundary between these systems, after which, for the next three miles, it gradually enters upon the older rocks and then turns due south and follows that course till it falls in the rocky delta of the French River.

Huronian rocks on Wahnapitæ River.

The rocks which it traverses in the upper nine miles referred to, consist of thinly bedded and more or less felsitic quartzites which have evidently been affected by pressure and shearing and generally show a fluted, striated or ligniform appearance on the bed-planes. They are mostly light grey and fine grained. The strike is north-eastward and the angles of inclination are always high. They are sometimes interstratified by slatey bands.

Supposed fault.

The line of junction between the Laurentian and Huronian systems runs unusually straight, in a nearly north-eastward course from the township of Broder to beyond the Wahnapitæ. It is not improbable that a considerable fault coincides with this section of the common boundary between the two series, as the strike of the adjacent Huronian rocks is not always parallel to the course of the dividing line. An example of this may be seen where the Canadian Pacific Railway crosses the river, the line between the two sets of rocks being here in the bed of the stream. If the course of this supposed fault be continued north-eastward, from a point where the boundary turns more to the east, it would cross the outlet of Wash-ki-gamog Lake where

Disturbed strata.

the Huronian strata are greatly disturbed and the clay-slates altered in character, as was first noticed by Mr. Murray in 1856.† The only

* Geological Survey Report for 1875-76, page 296.

†Geological Survey Report for 1853-56, page 174.

other rocks observed on or near this part of the Wahnapitæ were two exposures of greenstone and the band of dolomite mentioned above.

Rocks of Lake Wahnapitæ.

Quartzites are the prevailing rocks on the south side of Lake Wahnapitæ and on most of the adjacent islands and they are also largely developed along the valley of the upper Wahnapitæ River to beyond the north limit of the sheet. They are fine grained and mostly massive along both sides of this part of the river. The strike is everywhere north-westward and the inclination at high angles; but in some places the stratification is very obscure. Greywackes and volcanic ash-beds occur between this part of the stream and Vermilion River and will be described in connection with the geology of the latter.

Disturbance and mingling of rocks.

At the west side of Lake Wahnapitæ, where the Huronian strata come into contact with the Laurentian syenites or granites and gneisses, there is evidence of great disturbance and crushing, the rocks of the two series being much broken up and intermixed along the junction. This is what might have been expected where a point of the older and more solid and resisting set extends so far into the midst of the other, which almost everywhere bears evidence of having sustained great lateral pressure. Specimens 1 to 4 in Professor Williams descriptive list in the appendix are from the largest island in the mouth of West Bay, which lies on the borders of the two systems.

North River.

In 1875 I examined North River or the chain of lakes with falls and rapids between them, which stretches northward from the south end of Lake Mattagamashing to the edge of the sheet, and found only light coloured quartzites in that part of the route*. Since that time we have explored the country between this canoe-route and the Upper Wahnapitæ River and found the rocks to consist of quartzites also,

Upper Wahnapitæ River.

except a little argillite south-east of Sam Martin's Lake, a ridge of diorite, running north-west from the head of Boucher Lake, an area of diorite between Mattagamashing Lake and Portage Bay and the high ridge of the same rock mentioned by Mr. Murray as occurring between this bay and the main body of Lake Wahnapitæ.

East of Lake Wahnapitæ.

On either side of a curving chain of lakes from Portage Bay to the eastern edge of the sheet, drab-coloured argillites and clay-slates are the prevailing rocks. In the central part of Mattagamashing Lake they pass into a somewhat slatey greywacke with pebbles of granite, or syenite, white quartz and a few of red jasper, usually sparingly scattered through it, constituting what Mr. Murray described as slate-conglomerate.

Slate-conglomerate.

On the south-east side of Portage Bay and thence north-eastward along Lake Mattagamashing to where it turns east, slate—or greywacke-

* Geological Survey Report for 1875-76, page 297.

conglomerate, is the prevailing rock; but from thence to Lake Maskinongéwagaming and in the country between these lakes it is bluish green and drab clay-slate with distinct cleavage. Drab-coloured greywacke-conglomerate is largely developed on the west side of Wash-ki-gamog Lake and dark greenish argillite on the east side, while green, red and grey quartzites are associated with these rocks around the southern part of this lake. Clay-slates and slate-conglomerates are found around Murray Lake and thence to Sturgeon River. In addition to the masses of diorite at the southern extremity and near the meeting of the two arms of Lake Mattagamashing, other comparatively small areas of the same rock occur on the western sides of both Lower Mattagamashing and Maskinongéwagaming Lakes, at the south end of Wash-ki-gamog and at the outlet of Murray Lake, and again in the fork of the Maskinongé and Sturgeon Rivers.

Diorite masses

Along the east shore of Lake Wahnapitæ and the north-western part of Lake Mattagamashing, the general eastward inclination of the strata is at tolerably high angles, but elsewhere, in the north-eastern corner of the sheet, the dips are comparatively low, ranging mostly from 10° to 30°, except at the south end of Lake Wash-ki-gamog, where there is much local disturbance with high dips. Indeed, the quartzites which make their appearance here may be brought up in connection with the continuation of the fault, which, as above stated, is supposed to run along the straight part of the Laurentian and Huronian boundary.

Angles of dip.

As Mr. Murray pointed out,* a gentle anticlinal seems to run northward up the basin of Lake Maskinongéwagaming, where the clay-slates are about horizontal and on either side dip to the east and the west at low angles.

A gentle anticlinal.

Massive dark grey or drab argillite is the principal rock all around Koo-ka-gaming Lake. On the west side of the narrows, near the north end, there is a thick bed of grey quartzite, in the argillite, dipping due east at an angle of 10°. Dark crystalline diorite forms a bluff on the east side at the north end of these narrows, and this rock is found on two islands off their south end, also on a point on the east side of the lake near its south end, and on some of the islands to the north and the south of this point. Around Edith Lake, which lies a short distance north of Mattagamashing Lake, the rocks are all drab-coloured argillites, lying nearly horizontally. Towards the northern part of the lake they become very silicious.

Koo-ka-gaming Lake.

Edith Lake.

Edith Lake has an elevation of more than 100 feet above Mattagamashing Lake, and from the mouth of the brook discharging the former,

Straight valley.

* Geological Survey Report, 1853-56, page 174.

a well marked valley, with high slopes on either side and paved along the bottom with naked boulders and cobble-stones, runs north-north-eastward in a very straight course for the junction of the Obabika River with the Sturgeon. Where the latter strikes the northern boundary of the Laurentian gneiss, two miles below the junction of the Maskinongé, it is deflected eastward at a right angle from its former course and then gradually enters the gneissic area. The details of the geology of the shores of Lake Wahnapitæ and of the route from Portage Bay on its east side to Sturgeon River, are so fully given in Mr. Murray's Report for 1856 that it will be unnecessary to repeat them here. (*See* Geological Survey Report for 1853-56, pages 171-179.)

Sturgeon River.

Murray's description.

General Description of Vermilion River.

Vermilion River rises in Ni-nip-ska-gaming Lake, a long narrow sheet of water lying about three miles east of Onaping Lake and running north and south or parallel to it. It discharges northward, but the outlet soon turns eastward, and then south-eastward, and holds this direction all the way to Onwatin Lake, about three miles north of the township of Garson. In this part of its course it cuts off the angle formed by Proudfoot's east-and-west and north-and-south lines, the post marking their intersection being about a mile east of the first intersection and two miles north of the second. My instrumental survey extended up to the east and-west intersection, or three miles beyond the northern edge of the sheet and our explorations reached a point six miles still further north. Below Ni-nip-ska-gaming Lake the river passes through Pi-mitchi-wanga, O-mitchi-wanga and Tonadus Lakes.

Source of Vermilion River.

Extent of survey.

From Proudfoot's east-and-west line all the way to Onwatin Lake, a distance of twenty-two miles in a straight line, the river passes through a succession of narrow lakes connected by stretches of rapid river flowing in rocky defiles and having usually one or two and sometimes more falls with portages in each stretch, so that the general descent must have a considerable grade. Previous to the present survey these lakes had no names and, for the sake of convenience of description, we were obliged to give them those which appear upon the map. The principal tributaries of this part of the river coming within the limits of the sheet are a brook from the east at its northern edge and Ka-wa-wa-ski gama River, a large branch from the west which falls into Fraser Lake.

Character of river.

Names.

Tributaries.

Stratified Huronian rocks extend down from the intersection of the river with Proudfoot's east-and-west line to the junction of Black Ash Brook, from the east side, a distance of eleven miles in a straight line, the

General character the rocks

course of the river being about south-east. Here the stream enters upon an area of hornblende-granite, micropegmatite and gneiss, and its course becomes about south for a distance of nearly eight miles or to the head of Bass Lake, where it emerges upon the volcanic breccia. Its general course over the latter rock is southward to Onwatin Lake, but it makes a large bend to the eastward at Marshy Lake, from which a canoe-route goes north-eastward to the West Bay of Wahnapitæ Lake.

Change in character of the river.

At Onwatin Lake an entire change takes place in both the character and the course of the river. So great is this change that the Indians regard Onwatin (Smooth or Calm) Lake as a river-head from which the stream below derives its name; Onwatin (not Vermilion) River being its Indian designation. It may here be remarked that, as a rule, all over the vast Archæan country inhabited by the Outchipwai Indians, most of the rivers bear the same names as the principal lakes, which in each case are regarded as their source. From Onwatin Lake the river flows with a gentle current, as a rule, all the way to Vermilion lake, in a general west-south-westerly direction, slightly bowed to the north-west, the distance in a straight line being twenty-seven miles; but its

Very tortuous stream.

channel is so exceedingly tortuous that the actual length of the stream is about three times as great. A fall of about fifty feet occurs at Larchwood, where the Canadian Pacific Railway crosses the river, but besides this there are only a few small rapids, although the river is frequently blocked by great jams of driftwood, each of which renders a portage necessary.

Relation of rivers to geological basin.

Throughout the above section the river flows entirely upon the same rock-formation. At Onwatin Lake, it enters upon the north side of the elongated basin of unaltered argillaceous sandstones and shales, and follows the gentle sweep of their strike all the way to Vermilion Lake, the two lakes lying in corresponding positions nearly at the geographical extremities of this member of the series. In Vermilion Lake the course of the river doubles round and now flows east-north-eastward to the north-west corner of Creighton. The general upward bearing of Whitson Creek coming from the opposite direction is in continuation of this course as far as the north-west corner of Garson, the two streams almost completely surrounding the central part of the

Level country devoid of lakes.

geological basin just referred to. The area thus included is tolerably level and is singularly devoid of streams or lakes, thus contrasting with the country outside of this basin. As will be seen by the map, the higher

Streams from the north.

granitic country to the north sends down numerous streams which all join the above section of the Vermilion at right angles. Those between Onwatin Lake and the junction of the Onaping before falling into the Vermilion unite to form the three streams called Pa-wa-tik (Rapid), Sagi-tchi-wai-a-gama (Swiftmouth), and Ping-wi-i-min-kan-

i-wi (Sand Cherry) Rivers, while the Vermilion itself above Onwatin Lake and also the Onaping have similar physiographical characters and belong to the same class.

From the above-mentioned point in the township of Creighton, where Whitson Creek joins the Vermilion, the general course of the latter turns at right angles and flows due south transverse to the strike of the gneisses and diorites as well as of the Huronian quartzites and schists, as far as McCharles Lake*, where it crosses the line of the Canadian Pacific Railway. Between Vermilion and McCharles lakes the river is interrupted by seven falls and rapids, requiring portages to be made in order to pass them.

River crosses the strike.

Seven portages.

From McCharles Lake the general course of the stream is west-south-west to its junction with the Spanish River at the west town-line of Foster, the distance being twenty-one miles. In this section it flows altogether upon the greywackes, quartzites, felsites, &c., of the lower local division of the Huronian rocks and in the direction of their average strike. Its width varies much, but its principal expansion is Lake Wabagizhik, on the north-west side of which there is a large area of diabase.

W.S.W. course to the mouth.

Geology of Vermilion River.

Following the above general description of Vermilion River, an account of its geology will now be given. Around the outlet of Omitchiwanga Lake, or four miles in a direct course above Proudfoot's east-and-west line, grey diabase is exposed and on the eastern shore of Tonadus Lake, at two miles and a half above this line the rocks consist of dark greenish-grey argillite. Greywacke of the same colour as the last named rock is exposed on the river at half a mile above the line.

Above Proudfoot's line.

Proudfoot's line was examined from the corner post for a distance of seven miles west or for six miles from the river, and the country was also explored for a short distance to the eastward of this post. No rock was observed between the river and the corner post, but eastward of the latter the rocks in the first mile consist of dark greenish-grey argillites, quartzose greywackes and greywackes containing hornblende, all striking N.W. and S. E. On the western shore of a good sized lake, a mile and a quarter east of the post, the last mentioned rocks are again exposed, while from its south-western extremity reddish hornblende-granite of medium texture extends to the south-westward.

East of Vermilion River.

*This lake, which extends for three miles and a half eastward of the Vermilion River in the township of Graham, was formerly called "Vermilion Lake" on the township map, but as this name was preoccupied by the larger lake in the township of Fairbank, another name became necessary and we called it McCharles Lake in honour of Mr. Æ. McCharles, who resides on its northern shore and is doing much to promote the mining industry.

West of Vermilion River.

As already stated the river intersects the east-and-west line referred to a short distance west of the first mile post. Following this line, the steep ascent on the west side of the river exposes a very dark coloured silicious conglomerate with small white quartz pebbles. Between the second and third mile posts (from the corner) the rocks are massive,

Greywacke-conglomerate.

coarse grey quartzite and grey quartzose or greywacke-conglomerate, the pebbles of which are mostly of white quartz and grey aplite or binary granite. The last exposure of this rock occurs about a quarter of a mile east of the three-mile post and the first one of Laurentian rock at one-eighth of a mile west of the same post. Between three and five miles and a-half (also from the same post) the rocks consist of very

Quartz-syenite.

massive but rather fine-grained light pink and grey aplite, with the exception of a streak, twenty or thirty yards in width, of green schist, containing cubes of iron pyrites and running a little east of north. At five miles and a-half a short interval of coarsely crystalline hornblende and felspar rock occurs, beyond which, to the seventh mile, there is a

Gneiss.

moderately fine-grained quartzose syenite-gneiss and a more coarsely crystalline quartz-felspar rock without foliation. After leaving the valley of the Vermilion River going west, Proudfoot's line passes over almost bare rock, with clumps of small Banksian pines as far as I followed it.

Below Proudfoot's line.

Below this line the river flows south-eastward till we reach Black Ash Brook and the general strike of the rocks is in the same direction. They consist of quartzites, greywackes, argillites and clay-slates. On the south-west side of Proudfoot's Lake (between the intersections of the two lines of the same name) there is a coarse grey quartzite, so massive that the lines of stratification can only be traced in some parts. The dip is N. E. $< 60°$. At the outlet of this lake or half a mile above

Quartzite conglomerate.

the intersection of Proudfoot's north-and-south line, a grey quartzite with small white quartz pebbles dips N. 20° W. $< 65°$. This abnormal dip is, perhaps, due to the proximity of an area of red hornblende-granite to the eastward of it. From this line, for three miles downward, grey or greenish grey and drab clay-slates, some of them suitable for flagging, are the only rocks exposed. The course of the river conforms with the strike, which is generally about S. 35° E. and the inclination is to the north-eastward at an average angle of 60°.

Black Ash Brook.

The river continues in the same general course for six miles more (nine miles in all from the line) to Black Ash Brook, where it passes off the Huronian system. The rocks for these six miles consist of quartzites, alternating with argillites and clay-slates, with some greywackes. An island at the commencement of this section was named

Camp Island.

Camp Island for the convenience of local description. In this vicinity a dark grey quartzite dips N. 30° W. at a high angle, while a few

chains further down the same rock dips N. 40° E. < 30°. Close to the latter, and apparently underlying it, there is a massive drab-coloured argillite which shows no stratification.

Campbell Lake. Campbell Lake, measuring upwards of a mile in each direction, was discovered at two miles and a-half north-east of Camp Island. Between the river and this lake several ridges of greywacke of different shades and textures were crossed, the strike being generally northward, but varying to 10°, 15° and even 20° to the east of north. On the shores of Campbell Lake the rocks consist of, (1) greywacke with patches of quartz pebbles, of all sizes, and silicious inclusions which weather to a sponge-like surface and, (2) silicious volcanic breccia, holding sponge-like quartz fragments and patches.

Camp Island to Proudfoot's line. On an exploration from Camp Island in the opposite direction, or south-west from the river, as far as Proudfoot's north-and-south line, the only rock met with was at three-quarters of a mile, and consisted of a fine-grained greywacke, which showed no stratification.

Pot-hole Falls. Three-quarters of a mile below Camp Island, massive quartzite appears, and at a quarter of a mile further massive greenish-drab argillite, striking N. 21° W., the dip being vertical. Pot-hole Falls, with a descent of thirty-five feet, occur at a mile and a-quarter below Camp Island. Here a cliff on the south-west side of the river shows sections of ancient pot-holes much larger than the present stream would appear capable of forming. In this vicinity massive greenish-drab argillite, massive ash-grey quartzite and grey silicious conglomerate with pebbles of hornblende-granite occur, striking, respectively, S. 62° W., S. 68° W. and N. 70° W. The bedding of the first and last is on edge, but in the other case the dip is S. 22° E. < 15°, showing the existence of a fault or other disturbance. Half a mile further down there is another fall, and here the rock is indurated greenish-drab clay-slate, striking due west vertically, while its cleavage, which is also vertical, runs N. 15° W.

Ka-ko-zhish Falls. Ka-ko-zhish Falls, twenty-five feet high, occur a little more than half a mile below the last fall. A dyke of diabase, over 100 feet wide, here runs N. 65° W. and greenish-drab clay-slates, on its north-east side, strike N. 20° W.; but ten chains further down where the river enters Otter Rock Lake, similar slates strike N. 50° W.

Otter Rock Lake. and dip N. 40° E. < 80°. On the east side of this lake the rock is fine-grained massive greywacke, while on the north side it is dark bluish clay-slate, striking N. 55° W. < 90°. A ridge of angular fragments of banded greenish-grey slate crosses this lake.

Gibson Lake. Bluffs of grey quartzite overlook the north-east side of Gibson Lake and a grey quartzite-conglomerate is found at its head. A short distance above the head of this lake there is a portage past a rapid, a quarter of a

mile long. At the foot of this rapid, the rock is a massive, rather coarse light grey quartzite, running N. 50° W. < 90°.

Mowat Lake.

Mowat Lake lies two miles and a half east of this point, and in the interval there are two ridges of massive grey quartzite. This lake is two miles long and discharges at its south-east extremity, where the rock is grey quartzite. But on its south-west side, greywacke occurs, passing into dark blue-grey slate and striking S. 65° E. < 90°. In the hills overlooking this side of the lake, dark coarse slate and grey quartzite are seen striking N. 50° W. < 90°. A traverse was also made south-west from the foot of the above portage as far as Ka-wa-wa-kash-ki-gama River, three miles distant and the following rocks were noted; at a quarter of a mile, light grey quartzite, striking north-west: at half a mile, dark grey greywacke without observed bedding; at one mile and a quarter, dark grey clay-slate, striking north-west; at two miles, a ridge of grey diabase, running about north and south. The last named river was explored for some distance up and down, but no fixed rock was found in its bed.

Ka-wa-wa-kash-ki-gama River.

First gneiss.

Glossy green schists appears at the mouth of Black Ash Brook and massive pink gneiss on the opposite side of the Vermilion, being the first occurrence of gneiss in descending the stream. Half a mile above the junction of the Ka-wa-wa-kash-ki-gama, reddish gneiss strikes N. 10° to 40° W., and half a mile below it a similar rock occurs with folded lamination. Reddish gneiss, with an occasional band of grey, continues for four miles and a half below the above branch river, the prevailing strike being N. N. E., but in one case it is N. N. W. At the end of this distance the river makes a very sharp elbow to the S. S. W., and falls over a large diabase dyke which runs N. N. E. From this dyke down to the head of Bass Lake, a distance of two miles and a half, the rocks consist of rather fine-grained dark reddish-grey hornblende granite. The same rock was found by exploration to extend to a distance of three miles eastward of this part of the river, and from other explorations we know that rather coarser varities of hornblende-granite, along with gneiss and some diorite, extend to the west side of Lake Wahnapitæ.

Large dyke.

East of river.

Bass Lake.

At the head of Bass Lake the river enters upon the dark volcanic breccia described in a former part of this report, and this rock is exposed in a number of places as far as Onwatin Lake. The strike is S. 35° W., at the above locality, and S. 40° W. half a mile above and again half a mile below Marshy Lake. The breccia is very massive as far as the head of the long rapid just before the river falls into Onwatin Lake, where it becomes coarsely slaty with a "lumpy" cleavage and strikes S. 45° W. At the outlet of Marshy Lake a dyke of rather light grey diabase about 400 feet wide crosses the river and appears to

Volcanic breccia.

Great diabase dyke.

run about ten degrees south of west and probably causes the great bend which the river makes in this part.

Onwatin to Vermilion Lake.

From Onwatin Lake all the way to Vermilion Lake, as already stated, the river flows with the strike along the north-western side of the basin of grey argillaceous sandstones interstratified with softer beds. From a point three miles and a half, in a straight line, from the inlet of Onwatin Lake as far as the middle of the township of Lumsden, all the numerous southward bends of the stream touch the outcropping edge of the same band of the formation, which, with a southward dip, sweeps round in a gentle northward curve between these points. In this interval the sandstones and the slaty beds are generally dark grey, and the latter are sometimes black. The sandstone is characterized by disseminated grains of transparent quartz and it also holds occasional ovate spots of a different hardness and a lighter colour than the average, measuring from a few inches up to three or four feet in diameter. These weather, on exposed surfaces, into oval and rounded depressions, the larger of which are locally known as "Nanabozhoo's snowshoe tracks." These are well seen on the rock-surfaces at Larchwood where the Canadian Pacific Railway crosses the river and they are again met with at Chelmsford on the opposite side of the synclinal. Below Larchwood the argillaceous sandstones with the oval depressions on weathered surfaces are exposed frequently in the banks of the river for the first half of the distance to Vermilion Lake. The dip is south-east at high angles and the strike very straight, the bedding never being curved or disturbed. In the lower half of the distance nothing but sand is to be seen along the river.

Character of sandstone.

Oval depressions in surface of rock.

Below Larchwood.

The rock just described under the name of argillaceous sandstone might also be called arkose or greywacke, but for the sake of distinction, these names are reserved for the rocks of the older division in this district, which generally bear more distinct evidence of being made up of the débris of granite or quartz-syenite. They have a great similarity to the dark grey silicious rocks which are scattered so abundantly in the form of boulders around the shores of James' Bay and over the country to the south and west, and which occur *in situ* on Long Island, Eastmain; and they also resemble the dark grey greywacke or felsitic sandstone at the mouth of Churchill River on the west side of Hudson Bay.

Comparison with similar rocks elsewhere.

The country on the south side of Vermilion Lake is hilly and somewhat rugged, the highest elevations being towards the west end. The rocks of these consist of coarse black schist full of foreign fragments, mostly of quartz-syenite. The cleavage strikes S. 60° W., and dips to the south-eastward at an angle of 55°, but no distinct bedding could be observed. These rocks form part of the black breccia band, else-

Vermilion Lake.

where described, and contain, as usual, a good deal of iron pyrites.

Black slate. Further east, on the south side of the lake, the rock is a fissile black slate with vertical cleavage, striking parallel to the shore. At the first portage below the lake, which is past a fall on lot 10, concession VI, Creighton, the black slate is full of cubes of iron pyrites. The cleavage is vertical and runs 5° north of west.

Mineral-bearing vein. On this lot, and only a short distance west of the portage, a good sized vein containing galena and iron pyrites cuts across the slate. Other veins in Fairbank and Creighton are being tested for gold.

River turns south. Whitson Creek from the east joins the river at the foot of this fall, and now the general course of the stream turns south and flows across the strike of the rocks as far as McCharles Lake, on the south side of the Sault Ste. Marie branch of the Canadian Pacific Railway. As already stated, the general descent of the river is rapid, and seven portages occur in the interval. On lot 11, concession V of Creighton,

Huronian rocks. about a mile below the first portage, grey quartzite and greywacke occur, striking S. 60° W. Greenish-grey fine grained hornblendic schist is met with on the next lot to the west (No. 12, con. V), and grey quartzite is found in Fairbank, two miles to the westward of this locality. Schist similar to the last occurs half-a mile above the second portage, which is at the north end of lot 1, concession III, Fairbank, about three miles from the first portage. Here the rocks are light and dark grey quartzites, containing much felspar and passing into greywacke. The strike is S. 60° W. Quartzite occurs on the north end of lot 3, concession III, a mile west of this portage, and it was traced thence south-westward for upwards of two miles, when it became flanked on either side by fine-grained gneiss.

Levy River. Along the north-western margin of the gneiss in the valley of Levy River to the north-eastward of this part of the Vermilion there is a belt of dark greenish-grey and almost black felsitic schist with chlorite and black mica in fine scales covering the cleavage surfaces. This

Rock like "hälleflinta." rock corresponds with the "hälleflinta" of Norway. It is exposed at Emma and Moore Lakes: also on the section of Levy River between them and for some distance to the northward of it, and again on the islands and points in the northern part of White Water Lake, as well as to the north-west of the boundary of the gneiss at the point where it is crossed by the Canadian Pacific Railway near this lake.

The third portage occurs two miles below the second on the south end of lot 11, con. II, Creighton. Here the rock is all a dark grey

Hornblende gneiss. hornblende-gneiss striking S. 60° W. At the fourth portage, half a mile further down there is a dark rather coarsely crystalline diorite, much pitted over most of the exposed surfaces. The fifth portage begins about a mile below the fourth, and is a quarter of a mile long.

Here the rock is reddish gneiss, mostly of light shades. Some parts of it, however, are coarse and massive, resembling granite and other parts finer and more darkly coloured than the average. The stratification is not very distinct, but it runs about west-south-west. At the foot of this portage, which is on the south end of lot 11, con. VI, Graham, a greenstone dyke, eleven feet wide, runs N. 73° E. The gneiss continues nearly to the head of the sixth portage on lot 1, con. IV, Denison. At this portage the rock is soft felsitic schist, the cleavage surfaces of which glisten with fine scales of mica. It passes into greywacke, some beds being massive and silicious, approaching quartzite. The strike is N. 55° W. $<$ 90°. Similar soft grey schist with finely glistening surfaces continues for a mile below the sixth portage. Here the cleavage is almost vertical with a south-westward strike, and the exposed edges are eroded into holes elongated in the direction of the cleavage. Half a mile below this portage the river touches the west town-line of Denison, where a ridge of diorite crosses it and several large quartz veins, with a westerly course, are found at the same locality. A little molybdenite was the only other mineral observed in these veins. Between the town-line of Graham and the crossing of the Canadian Pacific Railway, at the seventh portage, a massive fine-grained bluish-grey greywacke occurs, striking S. 80° W. $<$ 90°. At the head of the seventh portage the rock is bluish and greenish-grey soft felsitic schist, passing into greywacke, and striking S. 70° W. $<$ 90°. On the railway line, a short distance west of the river, there is a cutting through dark, and in parts almost black, splintery clay-slate. Following the line, at one-third of a mile west of the river, a massive grey greywacke, with a few beds of dark shale, stands nearly vertically and strikes N. 75° W. Grey greywacke, in beds from three inches to two feet in thickness, striking due west with a southward dip of 85°, continues to Whitefish Station on the north end of lot 1, con. I, Denison.

Reddish gneiss.

Felsitic schist.

Quartz veins.

Crossing of the railway.

The geology of the lower part of the river will now be described from the mouth upward to the intersection of the Canadian Pacific Railway. A long rapid occurs just before the Vermilion River joins the Spanish, necessitating a portage of three-quarters of a mile in length. At the lower end of this portage a grey schist, striking S. 45° W., occurs, while just above its upper extremity the rock is a yellow quartzite, striking S. 80° W., and dipping southward at an angle of 60°. In the rapids at the outlet of Lake Wabagizhik and on the first point on the north-west side of the lake a tough splintery grey diabase occurs, with calcspar in the joints, but to the north-westward of this rock there is a light grey quartzite which strikes S. 70° W. and comes out upon the river below the rapids just referred to. The promontory near the

Lower Vermilion River.

Lake Wabagizhik.

middle of the north-west side of the lake consists of a light grey quartzite with some beds of greywacke, but the rock of all the rest of the shore as far as the inlet appears to be a grey diabase, which, in some places, is mottled and more coarsely crystalline than the average.

Large area of diabase.

This forms part of a large area of this rock, extending from the northern part of Foster to the VIth concession of Lorne. Nickeliferous pyrrhotite has been found in this rock on lots 1 and 2, con. III, Nairn, and on lot 11, con. V, Lorne.

Lorne.

On the south side of the inlet of Lake Wabagizhik, a bluish-grey silicious argillite dips S. 60° E. < 10°. Two miles above this lake, or at the centre of lot 8, con. III, Lorne, the river falls 35 feet, nearly perpendicularly, over a dyke of fine-grained greenstone 30 feet wide running about S. 80° W., or parallel to the south side of this part of the river. The rock on the north side of this dyke is silicious greywacke schist, while on the south side it is light grey quartzite. The latter rock occurs at the next fall, half a mile further up.

Lake Ella.

Quartzites.

Lake Ella is connected with the Vermilion River by a short marshy channel in lot 6, con. II of Lorne. This lake is surrounded entirely with quartzites of different characters, excepting at the points and on

Dyke.

an island on the south side which form parts of a large dyke of speckled grey diabase running west-south-west. The general strike of the quartzites is nearly east and west. They contain some bands of an arkose character. On the point near the middle of the north-west side of the lake, two masses of greenstone from 50 to 100 feet in diameter are included in the quartzite, and on the next point to the south-west on this shore, a mass of the same rock mixed with fine-grained grey quartzite rests unconformably upon the eroded edges of the quartzite beds, with fragments of the latter of all sizes more or less mixed with greenstone, intervening.

Lorne.

Above Lake Ella a schistose greywacke is found on lot 5, con. III, Lorne. The course of the river, which is straight in this vicinity, is probably determined by a greenstone dyke running S. 36° W. along its south-eastern side. The next upward stretch of the stream is at right angles to the last and lies between two dykes of dark heavy decomposing greenstone, the first of which runs N. 40° W., and the other appears to be quite parallel to it at a distance of a quarter of a mile to the north-east. Light and dark grey and greenish grey quartzites prevail everywhere in this part of Lorne and continue thence into Louise. Between the two dykes just mentioned a grey felsitic quartzite dips S. 30° W. < 45°.

Louise.

Throughout the township of Louise and thence to the intersection of the Vermilion by the Canadian Pacific Railway, quartzites, generally largely mixed with felsitic material, are the only rocks met with

near the river. The dip is never less than 45° and is usually nearer the perpendicular. The commonest direction of the strike approaches east and west, but it varies greatly, especially in the vicinity of the greenstone area in the southern part of Denison and the northern part of Louise. Deposits of pyrrhotite have been found in connection with this latter rock at eight localities in concessions I and II of Denison and concession VI of Louise. Felsitic quartzites, or greywackes, with some quartzites of a purer kind are found throughout the Whitefish Indian Reserve, with the exception of a few comparatively small areas of greenstone. Pyrrhotite.

General Description of Spanish River.

The Spanish River having been topographically unknown above the township of Hyman, it became necessary to make a micrometer survey of it, between this locality and the northern boundary of the sheet. This was accomplished by going down stream from a point above the intersection of the Canadian Pacific Railway near Spanish Forks, and after reaching the township of Hyman, the geological examination of the river and the country on either side was continued all the way to the junction of Vermilion River. Micrometer survey.

At Spanish Forks, sixty-four miles by the railway, north-west of Sudbury, two large streams, one from the north and the other from the west, unite to form the main Spanish River, which is the largest stream flowing into Lake Huron west of French River. From the Forks, downward, the course of the Spanish is remarkably straight, bearing S. 13° E. for twenty-two miles, or to the north-west corner of the township of Hart. Here it assumes a course of S. 21° W. for six miles, or to The Elbow, where it turns north-west, forming less than a right angle with its former course and then, sweeping round a semicircle, it gains a point five miles west-south-west of The Elbow, from which it runs S. 15° W. for eighteen miles to the great south-west bend. From the latter, its course is a little north of east for eighteen miles further to the Great (N.E.) Bend in the southern part of Drury. Between the Great Bend and Lake Huron, a distance of forty-four miles, its course is tolerably straight and bears S. 73° W. Spanish Forks. Main courses of river.

The Canadian Pacific Railway crosses the Upper Spanish River three miles above Pogamasing Station, which is nine miles below Spanish Forks. At this station perpendicular cliffs of red hornblende-granite rise to a height of about three hundred feet above the river. Four miles below Pogamasing Station the stream enters a narrow valley with steep bluffs of red hornblende-granite on one side or the other and often on both sides. This character continues, with a few Crossing of Canadian Pacific railway. Narrow valley

short widenings of the valley and a few exceptions in the nature of the rocks forming its slopes, which will be described further on, till we arrive within four miles and a-half of the great south-west bend, where the river emerges upon the Huronian belt.

Rapids. Between Pogamasing and the great south-west bend there are many rapids in the river, but only five portages, and these all occur in the first three miles below The Elbow. Agnes River, from the north-

Branches. west, falls in at the fifth portage. The other principal tributaries are Blue Water River from the west, ten miles below Pogamasing, Onaping Creek from the east, three miles further down, Geneva Creek, also from the east, four miles below the last, and the West Branch, eight miles above the great south-west bend. Numerous rapids and falls occur between the last named locality and the Great (N.E.) Bend, but these will all be noticed in the geological description of the river.

Pogamasing Lake and the Chain of Lakes to the southward of it.

Position of the lake. Pogamasing Lake, of which a micrometer survey was made, lies parallel with the Spanish River, at an average distance of one mile west of it. The point at which the Canadian Pacific Railway crosses the river is opposite the middle of the lake and the brook which discharges it falls into the river one mile further up. There are three portages, all of about equal length, about half a mile in each case, from the river to the lake, one at each extremity and one at the middle. The lake

Dimensions of the lake. is ten miles in length and has an average width of three-quarters of a mile. Its surface, by barometric readings, is 77 feet over Spanish River at the intersection of the railway. A post of the Hudson's Bay Company, which has been long established, stands on an island in

Rocks. the centre of the lake, mid-way between its extremities. The rocks on the shores of the lake consist of the prevailing hornblende-granite, which is all red except on an island near the northern extremity, where it is grey, and dykes of diabase, which were observed in three places, all running nearly parallel with its greater length.

Chain of lakes. A canoe-route, following a chain of lakes with a general southward course, leaves a bay on the west side of Pogamasing Lake, two miles from its southern extremity. The first lake of this chain, four miles and a half long, was named Kennedy Lake in honour of Mr. T. J. Kennedy, C. E., of Pogamasing. From it the Mogo River flows south,

Another chain of lakes. and just below the lake is joined by a stream from another chain of lakes, which we also explored, leading from the southern extremity of Pogamasing Lake. After passing through three other lakes, Blue Water Lake, in the new township of Craig, is reached. A rapid and crooked river of the same name leaves the east side of this lake and

discharges its waters into Spanish River, only two miles and a half distant. The rocks along both of the above chains of lakes consist of red hornblende-granite, except at two miles south of the outlet of Kennedy Lake, where a band of green crystalline schist with a south-west strike crosses one of the lakes. Blue Water River, through its whole course, flows upon a band of dioritic and greywacke schists, which form a westward spur of the Straight Lake Huronian outlier, to be more fully described further on. Blue Water Lake. Rocks.

Geology of Spanish River.

As already stated, Spanish River was surveyed topographically, as well as geologically, from a point a few miles above the crossing of the Canadian Pacific Railway, north of Pogamasing station, to the township of Hyman, where I connected my work with the township survey; and below this the surveys of Mr. Murray and the Crown Lands Department are continuous, so that henceforward it was not necessary to do any more topographical work, and attention was given entirely to the geology. The rocks found along the river and by exploration on either side have been already referred to in the general geological description of the district, but for the sake of convenience of reference and for practical purposes further details of the geology of this stream will now be given. As in other parts of this report the distances stated will be understood to be measured in straight lines, and the bearings will all be by the compass. Extent of new survey. Geological details.

From the crossing of the Canadian Pacific Railway downward, the rocks all along the river consist of the prevailing reddish hornblende-granite of the surrounding country, which has a medium texture, until we arrive at a point six miles and a-half from Pogamasing station, or just below the junction of a brook from the east, where a narrow band of distinctly foliated red and grey gneiss crosses the river. Its general dip is south at an angle of 60°. This is in the run of a wider belt of gneiss which crosses the railway one mile to the eastward between mile-boards 491 and 492. The same belt continues to widen to the eastward and on the canoe-route between Bannerman and Onaping Lakes it has a breadth of about three miles. Reddish hornblende granite. Band of gneiss.

In the opposite direction, at two miles and a-half west of this occurrence of gneiss on the Spanish River, green schist, striking south-west, with the red hornblende-granite on either side of it, was found on one of the lakes of the chain running northward from Blue Water Lake. In the township of Craig the river enters at right angles upon a spur of the Straight Lake Huronian outlier in the 4th lot of the Vth concession. Blue Water River, from the lake of the same name, two miles and Green schist.

a-half to the westward in Craig, falls in at the north end of lot 3, concession IV.

Schists and greenstone on east side of the river.

The rocks of this spur are well exposed on the burnt hills on the east side of the river, opposite the mouth of this branch. They consist principally of schistose greywacke, mingled with massive and schistose greenstone. The greenstone occurs both in broken dyke-like forms, running in different directions, and more abundantly as irregular masses of all sizes, which have somewhat rounded borders. In the latter case the greenstone is serrated at the contact, the indentations corresponding with the abutting ends of the alternating hard and soft layers of the greywacke and taking the same direction as the latter, as if they had influenced the greenstone when it was in a soft state. The hard layers in the greywacke consist of fine grained to vitreous quartzite and vary from a fraction of an inch to several inches in thickness. The strike of the schist is N. 75° E. and the dip northward at angles of 70° to 80°. On mining location F, at this locality, a belt of the schistose greywacke, which weathers to a reddish brown colour, is strongly impregnated with pyrrhotite and pyrite, the proportion of these sulphides in some places being sufficient to constitute a self-roasting ore. No analysis of this ore has been made by the chemist of the Survey, but it is reported to contain a promising quantity of nickel.

Sulphides.

Westward continuation.

This spur of Huronian rocks was traced westward up the whole length of Blue Water River, but not beyond the lake of the same name. However, on the meridian line six miles westward of the west townline of Craig, the late Mr. Salter, P.L.S., indicated the occurrence of quartzite in the strike of this belt (W. by S.), and it is not improbable that it reappears there and may continue a considerable distance to the westward. Nickeliferous pyrrhotite was discovered and several mining locations were taken up along the Blue Water River subsequent to our survey of Spanish River and the exploration of Blue Water Lake and River by the late Mr. Francklyn, who was a member of the party.

Hornblende-granite.

Greywacke conglomerate.

About a mile and a-half below the Blue Water branch, on lot 2, con. III, the red hornblende-granite is again exposed and continues for four miles along the river with the exception of two exposures of greenstone, one of which is opposite the mouth of Onaping Creek. Greywacke-conglomerate makes its appearance at the above distance and the same rock is again seen half a-mile further down, where it is partly of a massive form and partly schistose. In some parts the rock is full of rounded pebbles of grey quartz-syenite. The strike is S. 35° W. At half a-mile and again at one mile below this the east bank of the river consists of reddish grey hornblende-granite, flanked on the west by soft greenish schist with a little dolomite. Coarse gneissoid schist

with included boulders makes its appearance at an eastward bend of the river a mile and a quarter above The Elbow. It strikes S. 60° W. and dips to the south-eastward at an angle of 70° under the red hornblende-granite. Schist holding boulders.

Just at The Elbow a narrow tongue of grey schistose greywacke extends south-eastward into the hornblende-granite, which is here of a greyish colour. A short distance northward of the river, about a mile below The Elbow, there is a bluff of bedded trappean rock resembling diorite, largely mixed with impure dolomite which weathers to a reddish brown colour. The bedding is vertical and strikes north-west and south-east. Two of the five portages above mentioned, occur close together at a mile and a-half below The Elbow. At the upper one the prevailing red hornblende-granite holds streaks of green schist and some small veins of a pure looking magnetite. Crystalline greenstone, supposed to belong to a dyke, running north-westward, appears in the bed of the river at the lowermost of these portages. Agnes River falls in from the northward three miles below The Elbow, or immediately opposite the head of the fifth portage. Opposite the foot of this portage there is a dyke of medium grained grey olivine diabase, 240 feet in width, running N. 40° W. Referring to a sample of this rock, Professor G. H. Williams says: "The microscope shows this specimen to be a fresh aggregate of olivine, reddish augite, plagioclase and ilmenite, with accessory apatite, and biotite. Its diabase or ophitic structure is very typical."—(See fuller description in Appendix I.) The dyke is exposed along the northern margin of the river. Above it rises a bank of boulders, 200 feet high, mixed with some gravel and earth, and forming a conspicuous feature in the valley. From its brink a level gravelly plain, off which the forest has been completely burnt, extends for more than a mile to the north-westward or to a large brook from that quarter which falls into the main stream a mile and a-quarter below Agnes River. A mile below the latter, a brook comes in from the southward and near it, patches of dolomite occur in the red hornblende-granite. Rocks at The Elbow. Impure dolomite. Magnetite. Large dyke. Bank of boulders 200 feet high. Dolomite.

Below these affluents, the Spanish River resumes its southerly course and the reddish hornblende-granite is exposed almost everywhere in the banks for a distance of seventeen miles or to the foot of a straight south-south-easterly stretch two miles long. The West Branch joins the main river two miles above the head of this stretch. Its upward course is about west for the first four miles, above which it turns northward and at one part it is said to come within about six miles of Blue Water Lake. Half-a-mile up this stream a rock consisting of a mixture of green schist and fragments of granite was met with. At the bend four miles up there was found a fine-grained "pinkish to brownish crypto-crystalline banded rock, which might be macroscopically described Granite for 17 miles. West Branch. Rocks of the West Branch.

as a banded jasper or felsite. The microscope shows that it is a clastic rock consisting mostly of quartz which has been almost wholly re-crystallized under the influence of intense pressure and that it has thus had the parallel structure developed in it by an elongation of its grains in one direction that is commonly known as "stretched." (See Professor Williams' description of specimen 36 in Appendix I.) Salter's first meridian west of his principal one passes through this locality, which corresponds with the north-west corner of township 111, and on the map of this survey quartzite is here indicated. It probably belongs to a band of Huronian rocks which does not extend quite so far east as Spanish River.

Salter's notes.

A mile below the long straight stretch of the river above referred to, and at a short distance back from the west bank, a bluff was found consisting of a coarsely crystalline blackish and greyish dioritic rock, apparently the side of a dyke. The next rock to be seen is at one mile further on, and consists of white and light yellowish-grey quartzite, dipping S. 40° E. $<$ 70°. A similar rock, with a bluff of greenstone rising above it, occurs three-quarters of a mile further down and dips N. 50° W. $<$ 60°. This is a mile and a-half above the south-western bend, below which the river turns at right angles and flows eastward as far as the township of Drury. At the bend itself there is a coarsely crystalline hornblende rock with pitted surfaces. Three miles and a-half below the bend the western town-line of Baldwin crosses the river and in that distance grey quartzites and greywackes are exposed, the strike varying from east to north-east with high angles of dip. A quarter of a mile above the town-line of Baldwin, two masses of greenstone occur in the quartzite, but both appear to be small. From the west town-line of Baldwin for the next two miles eastward, or across lots 12 to 9, inclusive, in concessions V and VI of that township, the rocks consist of grey and greenish-grey greywackes and greywacke-schists, the strike being from N. 60° to 65° E. and the dip nearly vertical.

Quartzites.

Hornblende rock.

In crossing lot 8, concession VI (Baldwin), the river, for a quarter of a mile, contracts to a narrow gorge with a fall of fifteen feet. At the upper end of this gorge the rock is a glossy greywacke schist, running N. 72° E. and at the lower end it is a dark grey clay-slate, running N. 77° E. $<$ 90°. From lot 7 to lot 5, concession VI, the rock is a fine-grained grey slaty sandstone running N. 72° E. $<$ 90°. On lot 4 of the same concession, a glossy black slate occurs on the south side opposite an island in the river. A grey glossy ligniform schist striking N. 75° E. $<$ 90° is exposed for some distance along the river on lot 2, near the foot of a large island. On lot 1, concession VI, just below this large island, the rocks in the bed of the river consist of fine-grained

Narrow gorge.

Black slate.

pink quartzite, in thin layers, interstratified with rough-surfaced black slate, dipping southward at a high angle, while at a greater elevation there is exposed a heavy band of dark green mica-schist forming the top of a long ridge. Pink quartzite. Mica schist.

A traverse was made across the township of Hyman along its western town-line and the rocks were found to be as follows: In the southern half of concession I, they are light coloured quartzites and silicious greywackes, while in the northern half a bluish grey slaty greywacke prevails. At one place this contains a band of garnetiferous hornblende biotite "augen" gneiss, which, although a normal rock of that name, evidently forms a part of the quartzite and greywacke series in which it is incorporated. The geological relations and microscopical character of this rock indicate clearly that it has been metamorphosed out of some clastic whose composition has been favourable to the change under the conditions to which it has been subjected. It corresponds with No. 34 of Professor Williams' list in Appendix I (*q. v.*). In the southern part of concession II, a green glistening schist with rounded concretions was met with, followed near the middle of the same concession by a flaggy grey ribboned quartzite. A short distance north of the post between concessions II and III the town-line passes over a hill of light grey quartzite. A greenstone dyke running S. 78° W. was met with in the southern part of concession IV. This was followed at a short distance northward by a hill of slaty quartzite and in the middle of this concession by another hill of a more solid variety of the same rock, running N. 85° W., with a nearly vertical dip. Dark grey silicious greywackes were found in concessions V and VI. Boulders of red hornblende-granite became more abundant before reaching the north-west corner post of Hyman and this rock had been ascertained to occur *in situ* a short distance further north in the course of a traverse which had been made by the writer, eastward from the junction of the West Branch with the main Spanish River. Rocks in Hyman. Gneiss. Genesis of the gneiss. Quartzites. Hornblende granite.

Another traverse was made to the south of the Spanish River along the town-line between Baldwin and Nairn, which is a continuation of the line just described. On leaving the river in this direction a ridge of close-grained diorite was found to run south-westward across the middle of concession VI. This is followed by greenish-grey felsitic quartzite or greywacke in the southern part of the same concession. White quartzite was met with across the whole of concession V and into concession IV, and from our examinations elsewhere, quartzites appear to extend to the Spanish River on the opposite side of the Great Bend. Traverse south from Spanish River.

Continuing down Spanish River from the intersection of this township boundary, dark grey diabase is met with at the south-east corner Rocks of Spanish River.

of lot 12, con. I, of Hyman. This exposure is on the north-west side of a mass which appears to be more than a mile in length in a north-easterly direction. At the narrows of the river on the east side of the same lot there is a coarse grey glistening schist and a small quantity of a dark greenstone. Below the narrows on the next lot (11 in the 1st con.) a glossy dark bluish grey schist and a slaty greywacke strike north-east along the flank of the above-mentioned diabase mass. A fine-grained hornblende rock also occurs at this locality. Close by, where the line between lots 10 and 11 intersects the north bank of the river, quartzite occurs, dipping south at an angle of 55°. In the north-west part of lot 9, con. I, a dyke of gabbro, 70 feet wide, crosses the river with a north-west course.

Glistening schist.

Dyke.

Where the river enters the north-west corner of lot 8 con. I, there is a portage on the north side past a chute with a fall of 15 feet. Here there is an extensive exposure of rather fine-grained silver-grey mica schist, with crystals of staurolite thickly scattered over the cleavage surfaces. In the middle of lot 5, con. II of the same township (Hyman), the river passes through a rocky cañon, or narrows, with grey schist on the northern side and the northern flank of a ridge of fine-grained splintery greenstone running N. 70° E. on the southern. At a rapid in the north half of lot 3 con. II, a bluish-grey satiny schist strikes due north and south, the dip being east at an angle of 45°. This sudden change in the strike is accompanied by an equally sudden turn in the course of the river.

Mica schist with staurolite.

Satiny schist.

Kettle Fall.

Kettle Fall, with a descent of 20 feet, is on lot 2, con. II (Hyman). The rocks here are grey and satiny schists with a three-feet band of of nearly black hornblende schist, all striking N. 76° E. with a southerly dip of 75° There is a vein of hyaline quartz varying from 3 to 5 feet in thickness at this place, but no other mineral or ore was observed in it. Immediately below Kettle Fall the schists are disturbed, but at a short distance on they have a general dip to the west at an angle of 70°. The next portage is on the right side of the river, on the line between lots 2 and 1, con. I (Hyman) and opposite the west end of an island. Here the rock is a glossy grey finely-arenaceous schist, nearly on edge and striking N. 85° W. A grey glistening schist, standing vertically and striking N. 75° E., occurs at the fall on the south side of the island which has just been referred to. Nickeliferous pyrrhotite has been found in promising quantity on the southern side of a mass of greenstone on the north-east quarter of lot 3, con. I, Hyman.

Grey schists.

Drury.

The Spanish River enters the township of Drury in lot 12, con. I, and a hill of dark-coloured greenstone occurs on the south side of the stream on the same lot. A soft bluish-grey schist striking east-

Bluish grey schist.

ward with the course of the river is found on the next lot, 11, con. I, and on the north-east corner of lot 9, con. I, there is glossy green schist but without strong cleavage. On the south-east corner of the same lot a rather finely crystalline grey diorite forms a small hill between the river and the Canadian Pacific Railway which passes within a few hundred yards of the stream. Green schist.

From this lot the river enters the township of Lorne, and from the last-mentioned locality a soft greyish-green glistening schist continues for a mile down the stream. The next rock met with is in the southern part of lot 11, con. VI of Lorne, and consists of what appears to be a fine grained, greenish-grey silicious felsite with spots and threads of grass-green and pink colours. It does not exhibit any cleavage or bedding. A knob of tough splintery grey diorite occurs on the south end of lot 12, con. VI. Lorne. Green schist.

The river now passes into the township of Nairn. At a considerable fall on lot 1, con. V of this township, a dark, almost black, clay-slate is largely exposed. It strikes S. 80° W., and dips southward at an angle of 45°. A small hard black dyke was observed cutting these slates at the foot of the portage, which is on the south-east side of the river. Nairn. Dark clay-slate.

A distinct moraine, composed of boulders, cobble-stones and gravel, and causing a short steep rapid, crosses the river on lot 4, con. V of this township (Nairn). Its general course is about at right angles to that of the glacial striæ, which are distinctly seen a short distance above and below, bearing S. 60° W. On lot 5, con. V, half a mile below the intersection of the moraine, the striæ run under an overhanging rock on the north-west side of the river, grooving both the wall and roof. A greenstone area, rising in some parts into comparatively high bare hills, extends along the north-west side of the river from lot 6, con. V, to lot 11, con. III, a distance of three miles. The glacial groovings are very conspicuously displayed along the south-eastern flank of the greenstone on lot 6, con. IV. On lot 8, con. III, the greenstone is associated with hard green schist, the cleavage of which runs east and west. A grey hydro-mica schist, running south-west occurs where the Canadian Pacific Railway crosses the river in the centre of lot 11, con. II. In the south-west corner of Nairn the river makes a double or reversed curve like the letter S, in crossing a greenstone area, one portion of which is soft and another hard. Moraine. Striæ. Ice-grooved wall and roof. Greenstone area. Schists.

The Spanish River now crosses the north-west corner of the township of Foster. In the south-west corner of lot 12, con. VI, it falls twenty-five to thirty feet over a strong band of light grey quartzite, which dips due south at an angle of 70°. The Vermilion River joins the Spanish on lot 12, con. V, just below this fall, and as this brings Foster. Quartzite band.

us to the edge of the sheet the latter river was not followed any further and I proceeded to examine the Vermilion River. The late Mr. Alexander Murray made a topographical and geological survey of the Spanish River from this point to Lake Huron, as well as to a point above the Great Bend, but he did not work along the Vermilion.

Onaping Lake and River.

Topographical and Geological Description.

Form and position.

Onaping Lake is a long, narrow and straight sheet of water, running about due north and south (ast.) and having an elevation of 1,417 feet above the sea, as determined by barometer. Its southern extremity lies east a few degrees south, twelve miles from Pogamasing station and north a few degrees east, thirteen miles from Cartier station. It has a total length of about twenty-six miles. In the lower six miles or up to the intersection of Proudfoot's east-and-west line, its greatest breadth is a mile and a half, but north of that, it seldom exceeds half

Two outlets.

a mile and most of it is not over a quarter of a mile. It has two outlets. The smaller one, called Onaping Creek, from its most south-westerly extremity, flows south-westward and falls into Spanish River, thirteen miles below Pogamasing station. The larger is the Onaping River and it leaves the lake four miles and a half east-north-east of the first outlet, at the foot of a bay on the east side.

Courses of Onaping River.

The general course of the Onaping River is south-south-east and it joins the Vermilion one mile above Larchwood on the Canadian Pacific Railway, or twenty-four miles in a straight line from its head. In the first four miles, the course is south-east, then it is due south (ast.) to within four miles of its junction with the Vermilion, where it turns east by north to that stream. Besides numerous small brooks from

Branches.

both sides, it receives four good sized branches from the east, the first at three miles from the outlet, then Michaud's River at six miles, next a brook at one mile above the north townline of Levack and lastly Kinniwabik River, a quarter of a mile north of the southern town-line

Rapids and falls.

of the same township. It is interrupted by numerous rapids and falls all along, except in the last four miles. Onaping Lake is most

Route.

easily reached by canoe from the Canadian Pacific Railway at Bannerman Lake, by ascending Onaping Creek and some small lakes parallel to it, the distance being nine miles.

Dioritic breccia.

On the railway about a quarter of a mile west of Bannerman Lake there is a confused mixture of schists and dioritic breccia which may be on a line of disturbance extending south-westward from the southern extremity of Onaping Lake. A similar mixture is crossed on the Creek a mile and a half north-east of the railway, beyond which green

schists extend to a short distance north of the northern town-line of Moncrieff. Gneiss is exposed along the route in places for the next three miles northward and then red hornblende-granite and gneiss to Lower Onaping Lake. A spur of the latter rock runs north-east across the lake just named, but Huronian rocks are found on either side of it and they extend to the foot of Onaping Lake. These rocks here form an isolated basin measuring about four miles north-east and south-west by about three miles north-west and south-east. The principal varieties of rocks of this basin or outlier consist of slate-conglomerates with well rounded pebbles and boulders, mostly of binary granite, quartz, quartzite and schists and coarse arenaceous or greywacke conglomerates, together with some pale pink quartzites and bluish and greenish-grey felsites, argillites and slates. On an islet one mile south-west of the rapid at the head of the lake there is a brecciated mixture of dark hard slate, diorite and quartzite, while the rest of the islet consists of red felspathic quartzite, half altered into a fine grained binary granite. At various places around this lake, the matrix and finer parts of the greywacke-conglomerates appear to be undergoing alteration, or they show a tendency to pass into a granitoid rock.

Gneiss.

Huronian outlier.

Slate-conglomerate.

Other rocks.

Brecciated mixture.

Alteration into granite.

The basin of Onaping Lake appears to owe its origin to denuding agencies which have acted on a north and south dyke or set of dykes of greenstone, cutting the hornblende-granite, which, with some gneissic patches, is the country rock on both sides. The largest of these patches occurs at the wide part of the lake studded with islands, about half way up. Portions of a large dyke, running north-north-eastward, form some of the points and islands along the east shore, near the south end, and parallel to it an unusually long uninterrupted view may be obtained up the lake. Northward of Proudfoot's line sections of dykes and patches of greenstone adhering to the granite walls may be seen here and there all along. In the central part of the lake a narrow bay, on the west side, seven miles long, runs parallel to it, separated by a high tongue of land one mile wide. Towards the north end two narrow lakes, parallel to the main one and four miles long, occupy a position on the west side corresponding with this bay. Onaping Lake is surrounded on all sides by hummocky granite hills, which are comparatively low except on the sides of the narrow bay above mentioned, where they are three or four hundred feet high.

Origin of lake basin.

Large dyke.

Long narrow bay.

Surrounding country.

Gneiss occurs on the shores of the bay out of which Onaping River flows, but from the outlet for a mile and a-half we cross red hornblende-granite, and this is followed by six miles of red and grey gneiss. Below this the rock is again red hornblende-granite to the second concession of Levack. But about the middle of this concession, or a mile and

Geology of Onaping River.

Hornblende-granite.

a-quarter above the mouth of the Kinniwabik River, the north-west flank of a range of hills from the north-east comes to the river, the rock of which is very distinctly banded reddish-grey gneiss, which is much contorted and shows numerous small dislocations, but the general strike is S. 65 W. It is cut by irregular straggling dykes of greenstone, full of angular fragments of the wall rock. A dyke only two feet and a-half broad of nearly black porphyry, with widely scattered white crystals and running S. 55° W., cuts both the gneiss and the older dykes. Some coarsely crystalline veins of felspar which occur here hold large crystals of magnetite.

Distinctly banded gneiss.

Black porphyry.

Great belt of grey diabase.

The whole breadth of concession I of Levack, on the course of the river—upwards of a mile—is occupied by a transverse section of a great belt of rather coarsely crystalline grey diabase, which we have traced from the north-east corner of this township, south-westward into Trill, a distance of about eighteen miles. This belt is widest where it is crossed by the Onaping River, and gradually diminishes to a point at either extremity. To the north-eastward its course is marked by a straight valley, down which the lower part of the Kinniwabik River flows, but between the Onaping and Windy Lake it is covered by a great accumulation of sand, gravel and boulder-earth, forming hills in that direction. Windy Lake lies about mid-way on its course and, from this circumstance, it might be called, for distinction, the Windy Lake belt. The south-eastern boundary of this belt and the southern town-line of Levack intersect the river almost together, but at an angle with each other. Below this intersection the red hornblende-granite continues to be met with along the river for two miles, or to the junction of Windy Creek, below which the river enters upon the belt of dark silicious volcanic breccia and its underlying quartzite conglomerate. The falls of the Onaping River, close to the line of the Canadian Pacific Railway, are over this breccia. Between the foot of the falls and the junction of the river with the Vermilion, there are a few exposures of a coarse black slate, with large grains of quartz, overlying the breccia. The gneiss and hornblende-granite, above described, all along the Onaping River, are cut here and there by dykes of diabase, most of which have a northerly course.

Straight valley.

Windy Lake.

Hornblende granite.

Volcanic breccia.

Coarse black slate.

Dykes along Onaping River.

The Straight Lake Huronian Outlier.

Its extent.

This irregular basin of the upper rocks has a breadth of eight miles on the line of the Canadian Pacific Railway. It sends a spur westward as far as Blue Water Lake, in the township of Craig, and a longer one south-westward to The Elbow of Spanish River. These have already been referred to in connection with the description of this stream. We

propose to call this basin the Straight Lake outlier, as its rocks and deposits of economic minerals are already best known in connection with this lake and the railway station of the same name. Name.

The rocks within it consist principally of greywacke-schists, quartzites, quartzite or greywacke-conglomerates, green schists, hard sandstones, greenstones and some dolomites. In addition to these, black slates occur upon the western side of the first hill west of the outlet of Geneva Lake, and also, to a small extent, close to the outlet itself.* Rocks of the outlier.

The eastern lobe of the outlier surrounds Geneva Lake and is almost separated from the rest of the basin. The Canadian Pacific Railway passes the outlet of this lake which is three miles north of Cartier station. Coming from the south-east, on the line of the railway, different varieties of the common red hornblende-granite of the district are found to extend for two miles and a-quarter beyond Cartier, but here the granite becomes mixed with coarse breccia and conglomerate. This is followed by ash-grey greywacke, 100 yards in width, and next by a bed of fifteen feet of grey to dove-coloured fine-grained dolomite, weathering dark brown. The dolomite strikes N. 45° E. and the bedding is about vertical. It is followed to the northward by coarse felsitic sandstone and silicious greywacke-conglomerate or breccia. The pebbles and fragments in the latter weather out conspicuously and consist of other varieties of greywacke, hornblende-granites like the prevailing varieties found *in situ* in this region, black slate and black and white quartz. The strike varies from N. 30 to N. 60 E. These rocks continue, without change, for half a mile up the track and at the end of that distance they are found to enclose large masses or small areas of the greywacke, partially altered into fine-grained granite or syenite with all the outward appearance of the more thoroughly crystalline varieties. The rock also includes considerable masses of the latter and areas or patches of boulders of it crowded together, with the interstices filled by crushed or broken fragments of the same rock. At the outlet of Geneva Lake this syenite or granitic greywacke includes some black slate and a patch of impure dolomite thirty feet thick. A short distance northward of the outlet the greywacke becomes more argillaceous and shows lines of bedding dipping eastward at an angle of 45°, independent of the cleavage. Greywacke-conglomerate forms the shores of the outlet arm and of most of the western side of the lake, and it is also well seen along the railway track in the same vicinity. Geneva Lake. Coarse breccia. Dolomite. Conglomerate. Enclosed masses. Patches of boulders. Conglomerate on west shore of lake.

The rocks of the eastern part of Geneva Lake consist principally of light yellowish-grey quartzite containing a good deal of felspathic matter, but the islands in the mouth of the large bay on the south-east side Quartzite.

*These are probably a continuation of a band of black slates near Bannerman Lake examined by Dr. Selwyn in 1883.

Syenite. are formed of grey syenite, and an islet in the outlet arm is composed of the same rock. A mile and a-half north-east of the outlet there is an

Dolomite. islet of thinly bedded light grey, dove-coloured and whitish dolomite, striking N. 35° E. and dipping to the westward side at an angle of 80°. The rock is compact and has a conchoidal fracture, but it is traversed by threads of quartz which prevent it from taking a good polish. The same dolomite band is exposed on the point just southward of the above islet, but it could not be found on the northern side of the lake towards which it strikes.

At the north end of lot 1, con. I, Moncrieff, on the tote road at a distance of two miles north-north-west of Cartier station, the reddish hornblende-granite of the surrounding country becomes mixed with green diorite, having a dull fracture, enclosing fragments of grey granite and all mingled confusedly together forming a coarse breccia.

Coarse breccia On the west side of this is a massive fine grained rock having the general appearance of syenite or granite, but apparently resulting

Altered greywacke. Magnetite. from the alteration of massive greywacke. It is cut by numerous thin veins of quartz and fine grained magnetite, but the ore did not exceed six inches in thickness in any of the veins examined. A patch of brown-weathering dolomite, five or six feet in diameter, was observed in this rock. The hornblende-granite extends northward nearly to the fourth concession of Moncrieff.

Dyke. On lot 4, con. III, Moncrieff, there is a dyke seventy-five feet wide and running a little east of north, composed of greenish-grey coarsely crystalline diabase. The late Mr. Salter mentions trap-rock as occurring on his meridian line at what is now the north-west corner of Moncrieff. This would appear to be in the run of the above dyke. The junction of the Laurentian red hornblende-granite, on the south,

Greywacke. with the greywacke to the north occurs on the north end of the lot just mentioned. The latter rock is grey and somewhat thinly bedded and strikes S. 75° W. The tract between this and Bannerman Lake

Light greenish quartzite. is occupied by massive quartzite, some of which is of a light grassy green colour. At the west end of Bannerman Lake, a small belt of hornblende-schist in the quartzite shows the strike to be S. 70° W. < 90.

The breccia or volcanic agglomerate on the railway, a short distance north-west of Bannerman Lake, has been referred to in describing the route to Onaping Lake. The 485th mile-board stands on this rock. Half a mile further north-west and continuing thence for half a mile on, or to the crossing of Onaping Creek by the

Elongated quartz pebbles. railway, there is a dark blue or nearly black close-grained rock, holding long thin lenticular pebbles of grey quartzite. The strike is S. 60° W. In this interval, at a short distance north-east of the

Agglomerate. track, there is a ridge of coarse agglomerate. Quarter of a mile west

H. VEALEY, PHOTO. DESBARATS & SON, ENGR. & PH. MONTREAL.

ROAST YARD, COPPER CLIFF MINE, LOOKING EAST

of Onaping Creek, greywacke occurs, striking S. 65° W. Half a-mile further, in the same direction, a dyke of bluish-grey crystalline diabase, about 100 feet wide, appears and it continues parallel with the railway track – about W. N. W. – for a quarter of a mile. It weathers brown and decomposes at the joints and angles, leaving rounded or boulder-like masses. This brings us to the 487th mile-board. A dyke, which may be a continuation of the last, appears half a mile further on, and again on the north side of Straight Lake at a short distance east of the station of the same name. From the above mile-board to this station – about two miles and a-quarter – the country rock consists of grey slaty greywacke with small scales of light-coloured mica on the cleavage planes, which dip about S. 20° W. < 70°. Straight Lake station is near the commencement of the hornblende-granite and gneiss which continue thence all the way to the northern and western borders of the sheet.

Diabase dyke.

Slaty greywacke.

General Remarks on the Rocks of the District.

It will be seen from the foregoing report and from Professor Williams descriptions, that the Huronian rocks of the Sudbury district, as elsewhere, are largely of a volcanic nature. Many of them which are stratified and even distinctly sedimentary, may, nevertheless, have been primarily volcanic, but have become modified by the action of water. They have probably been volcanic ashes, dust, mud or other ejectamenta and may have been thrown directly into the sea, as there was probably little land, or possibly none at all, at that stage of the earth's history. Even molten matter poured into the sea might easily break up to form some of these deposits, or if in sufficient mass it might remain nearly intact and finally cool in that position, afterwards becoming covered and incorporated in the sedimentary strata. The dark silicious breccia, which, with a thickness of several thousand feet, runs from the township of Trill nearly to Wahnapitæ Lake, affords positive proof of volcanic action with explosive violence, on a large scale. This rock may, however, be of Lower Cambrian age.

Volcanic nature of Huronian rocks.

Original state.

Proof of volcanic activity.

The greywackes which constitute the most abundant class of rocks of the Huronian series in this district consist of granitic debris, more or less comminuted; and, out of the same materials, by the modifying action of water, a considerable proportion of the other rocks of the series could have been and probably were formed. The commonest form of the greywacke is a grey or ash-coloured rock, which in hand specimens resembles sandstone, but on the large scale it seldom shows very distinct bed-planes and is generally massive or has a tendency to coarse slaty cleavage. It breaks more easily than quartzite and may

Greywacke described.

ROAST YARD COPPER CLIFF MINE, LOOKING EAST

be readily bruised or scratched, showing that a considerable proportion of its components are softer than quartz. But under this name we may include several varieties, ranging from rocks approaching quartzites through different modifications, like sandstones, to others approaching argillites. At other times the rock is more or less filled with pebbles or broken fragments, or both, constituting conglomerates and breccias. Occasionally the finer materials act as a mere filling between closely crowded pebbles, angular fragments or boulders. With apparently similar composition and texture, the rock may be either roughly cleaved or slaty, or it may be amorphous. Both varieties may contain pebbles or fragments, or be tolerably free from them. The fragments, from the largest to the smallest size, usually consist of red and grey aplite or binary granite, and the matrix appears to be derived from the same rock, but in a more finely comminuted state. Most of the commoner varieties may be regarded as composed of this granite, reduced to a very finely fragmental condition, but with a considerable proportion remaining as good sized grains and small and large fragments.

Varieties.

Cleavable varieties.

Nature of enclosed fragments.

Slate-conglomerate.

When the greywacke becomes fine grained and slaty, with pebbles scattered through it, the rock may be called a slate-conglomerate, but the late Mr. Alexander Murray sometimes extended this term also to the more massive varieties containing pebbles and broken fragments, but without cleavage. In addition to granitic pebbles, the slate-conglomerates often contain others of red and black jasper and white quartz.

Metamorphism of greywacke.

Origin of quartzites and clay-slates.

The greywackes appear to be susceptible of being easily restored to crystallic granite again. In many places the characters and conditions of the rock, as seen on the large scale, and also when examined by the microscope, show that this metamorphism is going on. Under different physical conditions and variations in the composition, felsite, granite and gneiss have been formed out of it. The quartzites and clay-slates alternate with each other, or are found geographically close together and they appear to have resulted from the separation and arrangement of the constituents of greywacke by water, the grains of quartz, with a greater or less mixture of those of felspar, being deposited by themselves to form the quartzites and the finer and lighter mud being carried further on to form the slates.

Quartzites.

Quartzites diminish towards the N.E.

The quartzites of the Huronian system may be regarded as the more silicious forms of the same rocks or those varieties which have been rendered comparatively free from the felsitic or softer constituents of greywackes. It is worthy of remark that the quarzites which form so large a proportion of the Huronian rocks along the north shore of Lake Huron and thence inland as far as the Great Bend of the Spanish River and the township of Broder in the north-eastern extension of the

belt, diminish greatly in volume and pass into greywackes, and further on, into clay-slates, before reaching the eastern margin of the sheet. It would be noticed, however, from the descriptions in a former part of this report, that in the country to the northward of Lake Wahnapitæ, the quartzites again become largely developed. As a general rule the different subdivisions of the Huronian rocks in any region, do not maintain their thickness very far on the strike, but diminish more or less rapidly to a point, their places being at the same time filled by a corresponding thickening of the members on either side. The quartzites do not appear to form an exception to this condition, but owing to the fact that they withstand denudation better than the majority of the rocks associated with them, they become more conspicuous in proportion to their volume than the others, and their relative proportions are therefore apt to be over-estimated.

Again developed.

Prominence of quartzites.

The clay-slates and quartzites are generally closely associated together, and both are found in connection with the greywackes. This is the case in the country between the Wahnapitæ and Sturgeon Rivers, and the same thing was observed along Montreal River and between it and Lake Temagami. These slates are generally drab or bluish-green, or brownish and purplish. They are sometimes distinctly banded across the cleavage-plans; and at the northern outlet of Lake Temagami, where a handsome greenish variety occurs, they are streaked with irregular and interrupted black bars, which consist of hornblendic material. This variety was much prized by the ancient Indians as an ornamental stone and a variety of articles made from it have been found in many places in the Provinces of Ontario and Quebec and in several of the Northern States.

Clay-slates.

As already stated, the trappean rocks of the district consist of (1) extensive masses, together with many of smaller size, incorporated with the other Huronian rocks and probably contemporaneous with them, and (2) dykes which cut through all the members of the series. The following are the three principal varieties of the first class. Within the area of the first division shown on the sheet there are nearly fifty masses of highly crystalline diorite of a medium texture, and a dark green or greyish-green colour, characterized by the presence of disseminated spots and crystals of pyrite or sometimes of pyrrhotite or chalcopyrite. These masses constitute the first variety and they are generally, but not always, considerably elongated in the direction of the strike of the adjoining rocks. They measure from less than a quarter of a mile to about eleven miles in length. The strata among which they are included, being now highly inclined, these elongated masses may represent sections of what were originally overflows of the molten rock upon the then nearly horizontal surface, while those having

Greenstones.

Fifty areas of diorite.

Elongated.

The reason.

more compact outlines may have filled hollows or they may have been early intrusive masses.

Character of country.

These greenstone areas are not marked by any constant topographical characters by which they may be recognized. The surface of the country which they occupy does not differ from that of most other rocks, except in a few cases. These areas are diversified by lakes and streams, much in the same manner as that of the latter. This may be due to the fact that different parts of the same masses decompose differently under eroding agencies, some portions yielding readily, while others are hard and resisting.

Coarse grey diabase.

The second variety is a massive grey rock, generally more coarsely crystalline than the last, and always appears to be a diabase or to consist principally of pyroxene and felspar. In this the above-mentioned sulphides are generally more sparingly disseminated than in the first class.

Two belts.

There are two principal belts of this rock, both of them cutting the Laurentian and both having a general north-easterly and south-westerly course. One of them runs from Whitson Lake south-westward into the township of Creighton. It has a breadth of about one mile and a-half in the middle and diminishes regularly towards each end. The other large belt of this variety has been traced from the north-east portion of Levack south-westward across Windy Lake, nearly to Hyman, a distance of about eighteen miles. It is upwards of a mile wide in the middle and runs to a point in either direction. This

Windy Lake belt.

has already been referred to as the Windy Lake belt, in describing the geology of the Onaping River. A third belt, about five miles long, from the vicinity of Sagi-tchi-wai-a-ga-mog Lake, runs south-westward into Morgan.

Slaty and brecciated diorites.

The third variety is a more or less slaty greenish diorite, which in places becomes brecciated, the included fragments being of all sizes, from very large boulders down to small pebbles, and consisting principally of quartzites and granites or syenites. The diorite belt which borders the south-eastern side of the tongue of granite and gneiss from Garson to Graham belongs to this class, as does also the belt in the Vth and VIth concessions of Denison.

Coarse crystalline hornblende-rock.

There is also a very coarsely crystalline dark green amphibolite or hornblende-rock, examples of which may be seen on lot 4, concession V, Blezard, just east of the Stobie mine; along the north-west side of the same belt in the Vth concession of McKim; near the McConnell mine in the IVth concession of Snider, and again at the south-west bend of the Spanish River.

Quartziferous hornblende-rock.

A massive quartziferous hornblende-rock or diorite is not uncommon in the Huronian series in other regions, but in the Sudbury district we have what may be a form of this rock, modified by water—a rock which

may be called a stratified quartz-diorite. It is made up of rather thin beds, the lower part of each of which consists of a layer of quartz grains, the coarser being at the bottom and the finer higher up, while the upper part is a mixture of hornblende and felspar debris.

Gneiss and felsite.

Reference has already been made to the apparent alteration of greywacke into granite in the township of Moncrieff and around Lower Lake Onaping and also as to the passage of another variety of greywacke into gneiss in the township of Hyman. Some of the gneiss on lots 10 and 11 in concession III of Garson bears a strong resemblance to the latter and it is possible that much of the gneiss of the long inliers of the contracted portion of the Huronian belt in the Sudbury district may have resulted from the metamorphism of greywacke.

Altered greywacke.

In the centre of the township of McKim a belt of altered greywacke runs from the Copper Cliff mine and smelting works north-eastward to the VIth concession. Professor Williams describes an average specimen of this rock from lot 6 concession IV, about three-quarters of a mile north of Sudbury, as a pale grey compact felsite, and its components do not differ from those of unaltered greywacke except that they have lost their clastic appearance. On the railway track, one mile north-west of Sudbury, there is a more compact and silicious variety of this rock, which, on a fresh surface exposed in a cutting, shows bunches or spots, each a few inches in diameter, marked by long scattered imperfect crystals of black hornblende. At a short distance off these bunches have the appearance of foreign inclusions, but on closer examination they were found to be continuous with the rest of the rock. On lot 4, concession VI of McKim, about a mile south of the Stobie mine, where this belt of rock is pinching out, it shows a distinct gneissoid structure, both macroscopically and microscopically. In some places near the south-eastern margin of this area of altered greywacke, there is a rather fine-grained, ash-coloured rock, which might be called an altered volcanic mud, in some parts of which white grains of andesine are disseminated. Dr. Selwyn has called this variety "rice-rock." Examples of it may be found near the Canadian Copper Company's smelting furnace, on the hill north of Sudbury and again on lot 5, concession III of McKim. It also occurs at Lake Panache.

Hornblendic bunches.

"Rice-rock."

GENERAL CHARACTER OF THE HURONIAN ROCKS OF THE DISTRICT.

Classes of rocks.

The descriptions of the field geology of the district in the foregoing pages and those of Professor Williams of the microscopical characters of the rocks contained in Appendix I, show that the Huronian belt in this district is made up of igneous or crystalline masses, metamorphic rocks derived both from these and from sedimentary strata, together with

unaltered or only slightly changed clastics, which have been generally sedimentary, but with some exceptions.

Their metamorphism.

Notwithstanding the sedimentary character of a considsrable proportion of these rocks, even they appear to have been nearly all derived directly from igneous or volcanic products, by undergoing a greater or less modification by water. Since their consolidation they have been subjected to metamorphosing influences, and have been more or less altered according to the different local conditions, such as their attitude, exposure to pressure, shearing, &c., as well as their own inherent susceptibility to change. They may, therefore, as a class, be appropriately termed pyroclastic. The primarily volcanic, as well as the derived rocks, have also undergone some degree of change, as, for example, in the case of the volcanic glass-breccia above referred to, (whether Huronian or a little newer) where the pumice has been completely silicified, and again in the case of some of the diorites, which were originally massive, but in which a textural change and a schistose cleavage have been developed. A careful study of these rocks, both in the field and under the microscope, in connection with such points as the above, might throw much light on various questions regarding the metamorphism of rocks in general.

Pyroclastic rocks.

Changes in massive diorites.

Economic Minerals.

Nickel and copper.

Nickel and Copper.—In the Sudbury district these metals are so intimately associated as to make it necessary to describe them together. They occur as mixtures of chalcopyrite and nickeliferous pyrrhotite. In some instances the copper is in larger proportion than the nickel, but in perhaps the majority of cases the percentage of nickel predominates. The principal occurrences of these ores yet known are indicated on the accompanying map, from which it will be seen that they are always associated with the greenstones and also that their commonest situation is at the contact of these with some other rock, especially granite or gneiss. These mixed ores have now been found over an area extending on the strike, from the Wallace mine, on Lake Huron, north-eastward to the northern shore of Lake Wahnapitæ and transversely from the south-eastern boundary of the Huronian belt in this district north-westward to the western part of the Straight Lake outlier, beyond the Spanish River.

Occurrences shown on map.

Area of occurrence.

Associated with the greenstones.

The ores are always found in intimate association with the greenstones, and in addition to the economic occurrences, these rocks always hold specks, crystals and often small patches of both pyrrhotite and chalcopyrite disseminated more or less abundantly throughout their mass. The existence of nickel in the sulphides of these greenstones

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GENERAL VIEW OF MURRAY MINE, LOOKING NORTH-WEST.

was first ascertained by Dr. T. S. Hunt in 1856. Mr. Alexander Murray, assistant provincial geologist, in that year explored Salter's meridian line, running northward from Whitefish Lake and in what is now the township of Waters he found a "green magnetic trap," of which he says:* "Specimens of this trap have been given to Mr. Hunt for analysis and the result of his investigations shows that it contains magnetic iron ore and magnetic iron pyrites generally disseminated through the rock, the former in very small grains; titaniferous iron was found associated with the magnetic ore, and a small quantity of nickel and copper with the pyrites." First discovery.

Mr. Murray visited the Wallace mine in 1848 and collected samples of the ore. In his report for that year (page 44) he says: "With a view of ascertaining the quality of the nickeliferous portion of the ore, a specimen of it, as free as possible from the copper pyrites, was submitted to analysis by Mr. Hunt, who found it to contain 8·26 per cent. of nickel with a trace of cobalt; but as nearly two-fifths of the specimen consisted of earthy materials, which might readily be separated by dressing, the quantity of nickel in the pure ore which this would represent would equal nearly 14 per cent." Wallace Mine in 1848.

In the Sudbury district, pyrrhotite is more generally diffused and more abundant than in any other known region of Canada and the unusual richness of this pyrrhotite in nickel, as compared with that of other parts of the Dominion, is somewhat remarkable. The latter circumstance may point to a common deep-seated origin of the accompanying greenstones, whether they occur at the surface among the Huronian or the Laurentian rocks. Abundance of pyrrhotite.

The causes which brought about the deposition of the ore-bodies in their present positions and the mode of their formation are not very manifest.

It has been already stated that the larger ore-masses are found principally at the junction of the greenstones with some other rock. But there is also another circumstance which appears to influence the occurrence or localization of the ores, namely, the crossing of these lines of junction by lines of fracture or by the greenstone dykes which cut all the rocks. Some of the greenstones along certain lines hold abundance of angular fragments of other rocks, especially quartzites, and this brecciated condition appears to be favourable to the accumulation of the ore. This variety of the rock is found near the Dominion or Blezard, the Stobie, Copper Cliff, Crean and Vermilion mines. Determining causes.

The larger ore-bodies all resemble each other in most respects. Their general outline appears to be approximately lenticular, judging Form of ore bodies.

* Report of Progress of the Geological Survey for 1853–56, page 180.

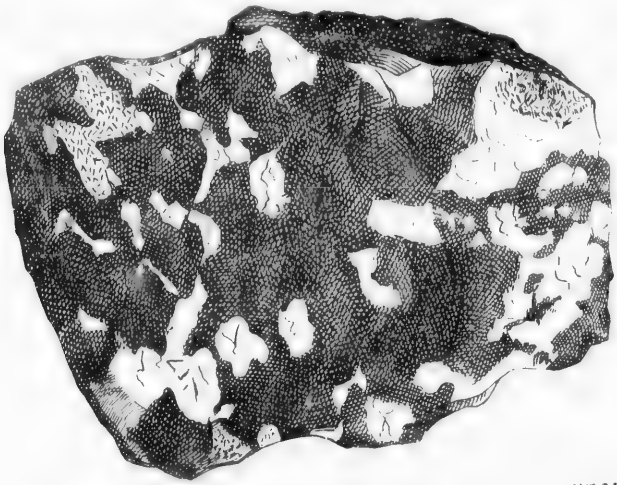
GENERAL VIEW OF MURRAY MINE, LOOKING NORTH-WEST.

from the surface indications, but none of them have yet been sufficiently worked to prove their form, in depth. Their greatest superficial diameter is always parallel to the general strike of the enclosing rocks.

Brecciated mixture of ore and rock.

In each case the ore-mass consists of a brecciated or agglomerated mixture of the pyrrhotite and chalcopyrite along with the country rock.

FIGURE 1.



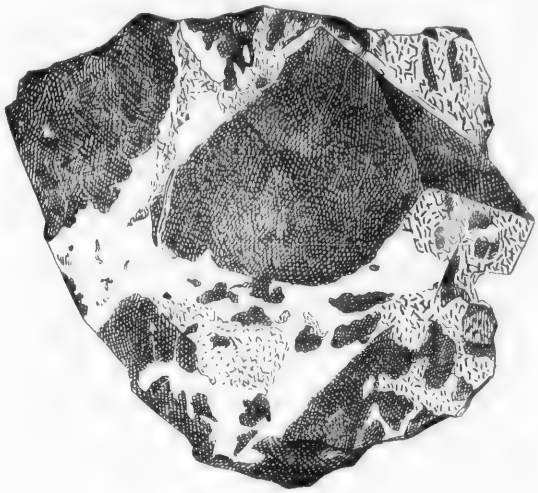
This figure represents a specimen, natural size, of ore from the Copper-cliff Mine.
The shaded portion represents diorite.
" white " " chalcopyrite.
" hatched " " pyrrhotite.

Mixed sulphides.

The included fragments of the latter are both rounded and angular, and vary in size from that of pebbles to large boulders, but the average is a few inches in diameter. Immense blocks or "horses" also occur in the midst of the ore, and at the Stobie mine some masses of the country rock run through the deposit in the form of thick walls or partitions, both transverse to and parallel with the general strike. Where the stony inclusions are widely separated, large quantities of the mixed sulphides have accumulated between them, but where the former are closely crowded together the amount of ore is correspondingly small. Besides being frequently intimately mixed together in the form of grains, the two sulphides are also commonly intermingled as spots and patches of all sizes. When the pyrrhotite is the more abundant ore, the patches of chalcopyrite may be said to be incorporated in it and vice versa, but the two interlock or ramify with each other so intimately that it is

impossible to separate by mechanical means even the coarser portions for metallurgical treatment, to say nothing of the finer mixture in the form of grains

FIGURE 2.



This figure represents a specimen, ¾ natural size, of ore from the Murray Mine.
The shaded portion represents diorite.
" white " " chalcopyrite.
" hatched " " pyrrhotite.

The chalcopyrite of the larger patches is generally nearly pure, but the pyrrhotite is almost always mixed with a considerable percentage of stony matter in the form of large and small grains. This may indicate that the former has been segregated out of the mixture by some secondary process subsequently to the general deposition of the mass. The chalcopyrite often shows a tendency to run in the form of branching strings or to partially surround the smaller stony inclusions. In one of these brecciated ore-deposits which occurs on lot 3, con. V of Levack, the spaces between the greenstone fragments are sometimes filled partly by pyrrhotite and partly by light-coloured crystalline granitoid vein-matter. This circumstance may be of interest in connection with questions as to the mode in which the spaces between the rocky fragments in all these deposits have been filled with ore.

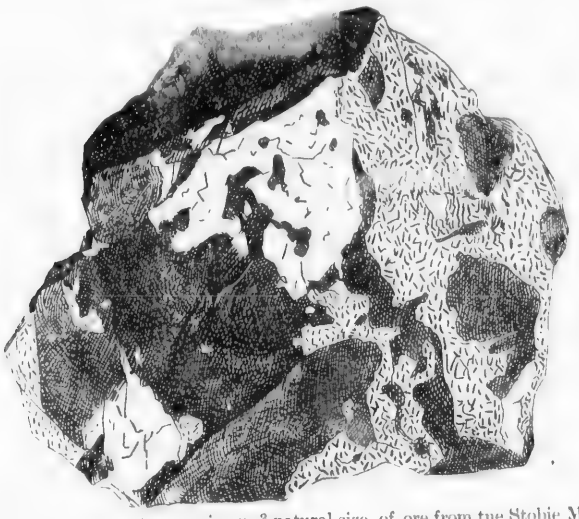
Impurities in the pyrrhotite

Granitoid filling.

The general character of the deposits seems to indicate that they have originated primarily from a state of fusion. Their intimate

Origin of the ore.

association with greenstones, which are of igneous origin, would show this, as well as the fact that these greenstones themselves fuse at



This figure represents a specimen, ⅔ natural size, of ore from the Stobie Mine.
The shaded portion represents diorite.
" white " " chalcopyrite.
" hatched " " pyrrhotite.

about the same temperature as the sulphides. But they may have been subsequently more or less modified by other agencies. The occurrence of crystals of felspar, quartz and apatite in some of the deposits, and of laminated iron pyrites in one place in the Copper Cliff mine indicate the action of aqueous solution.

Possible partial modification by solution.

Greenstones impregnated with the sulphides.

The greenstone wall-rocks of the deposits, as well as the included fragments of the same material, are generally much impregnated with these sulphides in the form of isolated globules or kernels, usually from the size of peas to that of hazel nuts, besides irregular strings and patches. A fresh surface of the rock will in one case show the two sulphides in separate spots thickly intermingled, while another section may show the spots to consist entirely of the one or the other. These disseminated sulphides exist in all proportions relatively to the greenstone matrix until they replace more than half the latter and constitute a self-roasting ore. To the south-west of the Stobie mine in the strike of the principal deposit there, smaller ore-masses are found for a distance of more than a mile, and these are connected with each other by a belt of somewhat slaty diorite full of disseminated ore of this kind. These impregnations have not been found in the clastic

Continuation of ore-bearing belt of Stobie mine.

rocks adjoining the greenstones at any of the deposits, while their abundance in the latter rocks goes to show that the larger or more concentrated deposits have also had an igneous origin like the smaller ones enclosed in the diorite.

Copper.

At the Vermilion mine, on lot 6, con. IV, Denison, a shaft called No. 1 had been sunk in diorite to a depth of about twenty feet on a promising vein of chalcopyrite. On exposure to the weather, the ore is remarkable for becoming tarnished of a deep purplish blue colour like that of bornite. The vein occurs in diorite, and is about four feet wide, but without distinct walls or any veinstone except a mixture of the country-rock. The upper ten feet were decomposed to a loose gossan, holding fragments of rock. The new mineral Sperrylite (arsenide of platinum with a little tin) was found by washing this material, and Mr. R. R. Hedley informed me that he had found 12 dwts. of gold to the ton in one assay of ore from this shaft. A few specks of gold were seen in iron-stained spots on the weathered surface of the diorite close to the shaft. At about fifty yards to the southward of the shaft, massive beds of quartzite and greywacke terminate abruptly almost at right angles against the cleavage of a dioritic schist holding large and somewhat angular fragments of quartzite, along with many small ones, all mingled together. A belt of diorite runs east and west across the township of Denison, in the Vth concession, and along its southern border, copper pyrites has been found on almost every lot, but as yet no openings have been made to test the extent of these deposits. Two or three masses of a fine-grained mixture of pyrite and blende occur on lot 10, con. VI of Creighton. They are said to be large, but we had not an opportunity of examining them.

Blue tarnish.

Sperrylite.

Gold.

Across Denison.

Pyrite and blende.

The mines from which ore has been sent to market or smelted in the district are the Stobie, the Copper Cliff and the Evans belonging to the Canadian Copper Company, the Blezard and the Worthington belonging to the Dominion Mineral Company, and the Murray mine belonging to Messrs. H. H. Vivian & Co. In order to ascertain the average percentage of nickel and copper as determined by the treatment of large quantities by these companies, I applied to the secretary of the Canadian Copper Company and the managers for the other two companies, all of whom have kindly furnished me with the desired information. On 18th March, 1891, Mr. H. P. McIntosh, secretary of the Canadian Copper Company wrote: "The output of our mines for last year averaged as follows:—

Percentage of metals in the ores.

Mines of the Canadian Copper Company.

	Copper.	Nickel.
Copper Cliff mine	6·24 per cent.	3·69 per cent.
Evans mine	2·84 "	3·62 "
Stobie mine	1·99 "	2·00 "
Average of all	4·32 "	3·52 "

You will note that the average of the total output is more than one third the total of the three mines; this is accounted for by estimating the average according to the amount of ore mined, which is the proper way. We have not done sufficient work at the Vermilion to give you any reliable data, but the ore taken out there, now on the dumps, assays about 16 per cent. copper and about 13 per cent. nickel."

Mines of the Dominion Mineral Company.

Mr. George Attwood, M.E., manager for the Dominion Mineral Company, under date of 18th March, 1891, wrote: "The 'Kies' or metallics of the Blezard mine average 4 per cent. nickel which is accompanied by about 2 per cent. copper. The above is the result of many hundreds of assays, also of the practical working on a large scale. The nickel ore at the Worthington varies very much, and we have had assays from 2 per cent. to 38 per cent. nickel. Large shipments of clean ore have gone about 9½ per cent. nickel and 3 per cent copper. We have also shipped some clean copper ore from the Worthington mine assaying 18 per cent. copper and 2½ per cent. nickel."

Vivian Co.'s mine.

Mr. F. R. W. Daw, manager for Messrs. H. H. Vivian & Co., writing on 20th March, 1891, said: "The average percentage of the ore smelted here (Murray mine) is as follows:—Nickel 1·5 per cent., copper 0·75 per cent. The matte or first metal will average 8·5 per cent. for nickel and 4 per cent. for copper."

Range of nickel contents.

The percentage of nickel in samples of the pyrrhotite ores from the numerous deposits of the district has generally been found to range from less than 2 per cent. to nearly 5 per cent., while selected specimens of the sulphides of nickel found at some of the mines have given from about 30 to 40 per cent.

Rich nickel ore.

The Dominion Mineral Company has shipped in the spring of 1891, a small quantity of dressed ore from the Worthington mine, containing in the neighbourhood of 30 per cent. nickel.

Proportions of nickel to copper.

From the description already given of the mixed nickel and copper ores of the Sudbury deposits, it would naturally be expected that the relative proportions of these metals would vary greatly. These variations are illustrated by the following tests: Mr. F. L. Sperry, late chemist to the Canadian Copper Company, in November, 1888, made assays of nine different samples of the ores from the mines of this company, and found them to show extremes of 1·12 per cent. and 4·21 per cent. of nickel, the average being 2·38 per cent. and of 4·03 per cent. and 9·98 per cent. of copper, the average of the latter being 6·44 per cent.

Mr. Sperry's tests.

Mr. Hoffmann's tests.

Mr. G. C. Hoffmann, chemist to the Geological Survey, had, in 1890, assayed four samples* of pyrrhotite from as many different

* Collected at the following localities:
Nairn, lot 2, con. III. Nickel, 1.95, with traces of cobalt.
Lorne, lot 11, con. V. Nickel, 1.95 with traces of cobalt.
Drury, lot 3, con. III. Nickel and cobalt, 2·01.
Neelon, lot 12, con. III. Nickel, 3.10.

deposits in the district, and found from 1·95 per cent. to 3·10 per cent. of nickel, the average being 2·25 per cent. Since that time, by your direction, analyses of eight samples of these ores from seven different localities have been made in the laboratory of the Survey with the following results:

They show the percentage of nickel contained in the samples just as they were collected, or without the separation of any portion of the gangue.

1. From S. ½ lot 6, concession II, Denison. Pyrrhotite, disseminated through a quartzose gangue. It contained nickel, 1·55 per cent.: cobalt, none.

2. From lot 7, con. II, Levack. Pyrrhotite disseminated through a quartzose gangue. It contained nickel, with a trace of cobalt, 2·36 per cent.

3. From lot 7, con. II, Levack (from a different part of the same deposit as the last). A coarse-grained pyrrhotite. It contained nickel, 4·13 per cent.; cobalt, none.

4. From lot 3, con. IV, Levack. Pyrrhotite with a little copper pyrites in a gangue of diorite. It contained nickel, with a trace of cobalt, 1·96 per cent.

5. Ross Location, 3 miles north of the centre of the north town-line of Morgan. Pyrrhotite with a small amount of copper pyrites. It contained nickel, 2·75 per cent.; cobalt, none.

6. Location W 7, east side of Waddell's Lake. Pyrrhotite with a little copper pyrites in a gangue of diorite. It contained nickel, 2·00 per cent.; cobalt, none.

7. Boucher's mine on the north-east side of Lake Wahnapitae. An intimate association of copper pyrites in a gangue of diorite. It contained nickel, 1·57 per cent.; cobalt, none.

8. Vein on lot 10, con. VI, Creighton. An association of a dark grey schistose rock and white quartz, carrying zinc-blende and some pyrrhotite. It contained neither nickel nor cobalt.

The above results are not intended to apply to other than the particular specimens examined.

Lead and zinc

Lead and zinc. Galena and zinc-blende have been found, but, as yet, apparently, only in small quantities, at several places in the belt of black slate and volcanic breccia. One of these is on lot 4, con. V of Fairbank, near the outlet of Vermilion Lake: another is on lot 8, con. IV of Dowling, near Onaping Falls, and a third occurs on the Pawatik or Rapid River, about a mile and a-quarter from Vermilion River, where Mr. Stobie informed me he had found these ores in small quartz veins cutting the breccia. A vein of blende and pyrite on lot 10, con. VI of Creighton, has been already mentioned.

Galena has been found in small quantities with the pyrrhotite at the Copper Cliff Mine, and on lot 6, con. III of Graham. It also occurs in small quartz veins in dioritic schist on lot 5, con. IV of Denison.

Gold.

Gold.—Fifteen samples collected in 1890 were submitted to Mr. Hoffmann for assay for gold and silver, and the following are his results:—

15 assays.

Locality.	Gold, per ton of 2,000 lbs.	Silver, per ton of 2,000 lbs.
Simon Obonsoing's mine on lot 8, con. III of Moncrieff		
Quartz, honeycombed by the dissolving away of iron pyrites	Trace.	None.
Vein of quartz, 50 feet wide, and running N. and S. on W. side of Little Clear Lake, 2 miles W. of dam at outlet of Lake Wahnapitæ	None.	do
Vein 9 inches wide on East side of Waddell's Lake	Trace.	do
Vein No. 1 on mining location W.R. III, township 40 (S.E. of Lake Wahnapitæ). Property of Mr. Donald McLaren	0·117 oz.	do
Vein No. 2 on same location	None.	do
Location M. III, at S. extremity of Lake Mattagamashing, a short distance N. E. of Lake Wahnapitæ. Property of Donald McLaren	1·167 oz.	6·233 oz.
Near line of C.P.Ry. 480¾ miles West of Montreal	Trace.	None.
N. E. corner township of Plummer. Silicious veinstone containing grey copper ore. From Mr. James Stobie	do	do
Middle of large vein of bluish-grey quartz, Ophir mine, Lot 12, con. III, Galbraith	0·175 oz.	do
Foot or North wall, West end Ophir mine	Trace.	do
Hanging, or South wall, West end Ophir mine	do	0·175 oz.
Near hanging wall, Eastern opening Ophir mine	0·583 oz.	None.
Lot 5, con. IV, Denison, No. 3 shaft	Trace.	0·525 oz.
E. ½ Ross location, 3 miles N. of middle of N. townline of Morgan (decomposed pyrites)	None.	None.
Simpson's mine, lot 11, con. II, Graham, near Whitefish Station on C. P. Ry.	0·350 oz.	do

Gold-bearing veins.

Numerous veins of quartz, some of which are of large size, have been discovered in the north-western part of Creighton and the eastern part of Fairbank. Their general course is N.N.E. Openings have been made on some of these veins by Mr. J. R. Gordon and specimens sent for assay to Prof. Heys, of Toronto, and others, who report the occurrence of gold in several instances.*

Limestone.

Magnesian limestone. The purer deposits of dolomite which have been described as occurring at Lake Panache and also those of Geneva Lake and near Cartier Station, as well as the band which crosses Wahnapitæ River at the Island Portage, are apparently suitable for burning into lime, and they may also be found useful in connection with metallurgical processes in the district.

* Specimens of quartz from gash veins in these townships have been assayed by Mr. Hoffmann with the following results:—
Fairbank, lot 2, con. IV. No gold or silver.
Creighton, lot 11, con. V. No gold or silver. (Two assays.)

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MATTE IN STOCK, COPPER CLIFF MINE
July, 1890.

MATTE IN STOCK, COPPER CLIFF MINE.
July, 1890.

APPENDIX I.

NOTES ON THE MICROSCOPICAL CHARACTER OF ROCKS FROM THE SUDBURY MINING DISTRICT, CANADA.*

By Prof. George H. Williams, Ph. D. (of Johns Hopkins University).

(Collected in 1889–90 by Dr. Robert Bell.)

The suite of rocks from the Sudbury mining district entrusted to me for examination consists of forty-seven specimens, exclusive of two from Labrador and one from Hudson's Bay.

These rocks consist largely of distinct clastics derived from granitic or gneissic debris. With them occur many undoubted eruptives, whose origin was contemporaneous or subsequent to the deposition of the clastics, and with which the origin of the ores appears to be intimately connected.

Both clastics and eruptives have been subjected to extensive metamorphism and recrystallization, which has frequently resulted in the partial or complete obliteration of the original structure. The writer has frequently insisted (Bull. U.S. Geol. Surv., No. 28, p. 9; Bull. Geol. Soc. Am., Vol. I, p. 552; etc.) that a definite sequence of physical condition may produce from rocks of the most diverse origin, ultimate results that are indistinguishable. An eruptive granite and a sedimentary arkose may, under like conditions, be so recrystallized and metamorphosed as to produce gneisses which the microscope cannot separate and upon whose origin this instrument is able to throw no certain light.

As illustrations of progressive changes of this character in both clastic and eruptive rocks, this suite of specimens from the Sudbury region is particularly instructive. We may find the typical arkose with its felspar just beginning to break down into sericite (Nos. 22 and 25); and we may trace this alteration to the development of a continuous sericite matrix in which the quartz grains of the original rock are imbedded (No. 8, 9, 12, 13, 18, etc.). In similar rocks we may also see the new crystallization biotite, epidote or chlorite. In this way gneisses may result which retain little or no trace of clastic structure, and which might have originated from the crushing of a granite (Nos. 19, 23, 26, 27, 30). Hence it is not to be wondered at that the origin of certain of the holocrystalline rocks must always remain in doubt.

* A similar collection of rocks from the Sudbury region has been described by Prof. T. G. Bonney (Quart. Jour. Geol. Soc., vol. 44, p. 32, Feb., 1888), who reaches about the same general conclusions in regard to them as the present writer.

Many of the intrusive rocks still retain, even when greatly weathered, the unmistakable signs of their true character and source. But these masses, like those of clastic origin, are subject to metamorphism and recrystallization under altered physical conditions, which may in time obliterate entirely the minerals and structures that are such certain guides as long as they survive. Such changes we may see in progress in the Copper Cliff rock (No. 5) while enough of the original character remains to definitely fix the nature of the mass. In Nos. 32 and 40, however, the metamorphism has progressed so far that we are only warranted in assigning the rocks to the class of eruptives, after having traced out the progress of their alterations step by step. No. 43 affords another example of such changes in progress in eruptive rocks, where, however, the nature of the alteration is quite different from that seen in No. 5.

Apart from their alterations, some of the eruptive rocks of this collection possess an unusual intrinsic interest. This is noticeably the case with No. 46, quartz-hypersthene gabbro; No. 39, variolite; No. 43, hornblendic pyroxenite; Nos. 35 and 42, vitrophyre tuff; and No. 47, micropegmatite.

Appended is a classified list of the fifty specimens, followed by descriptions of each one in regular succession.

I.—Rocks Whose Clastic Structure is Plainly Visible.

No. 1. Conglomerate. West side of largest island in the west bay of Wahnapitæ Lake.

24. Conglomerate sandstone or greywacke. South side of Bay Lake, Montreal River.

20. Conglomerate sandstone or greywacke. Five miles N. E. of inlet of Echo Lake, St. Mary's River.

9. Coarse arkose with sericite matrix. East side of Maple Mountain, South of Montreal River.

8. Finer arkose with sericite matrix. Sturgeon River, near junction of Obabika River.

12. Arkose with little sericite matrix. South side of Little River, Lake Temiscaming.

18. Arkose with much sericite matrix. Thirteen miles up Upper Wahnapitæ River.

22. Arkose with felspar in process of sericitization. Montreal River, four miles above Temagami Branch.

25. Arkose with felspar in process of sericitization. N. E. side mountain, near Wendabin's House, Lady Evelyn Lake.

No. 13. Quartzite grit with sericite matrix. High Pond, east side of Maple Mountain.

17. White sandstone, with kaolinized felspar. Four miles N. E. of inlet of Echo Lake.

28. Felspathic sandstone or quartzite. Gold Mine, south side of Wahnapitæ Lake.

II.—Rocks Distinctly Clastic, but Partially Recrystallized.

No. 36. Stretched quartzite. Three miles up West Branch of the Spanish River.

41. Arkose with granite fragments partially recrystallized. Quarter of a mile N. W. of Copper Cliff mine.

33. Sandstone, partly recrystallized. The Hill, north side of Sudbury Village.

14. Greywacke, with iron in felspar. 455½ miles west of Montreal, on main line of Canadian Pacific Railway.

III.—Highly Crystalline Rocks, Probably Derived from Clastics.

No. 6. Felsite. Canadian Pacific Railway track, between Sudbury and the Murray mine.

7. Felsite. 300 yards east of the Copper Cliff mine.

15. Felsite. North side of Copper Cliff mine.

16. Felsite. Southern part of Lady Evelyn Lake.

19. Felsite. Foot of first portage below Rabbit Lake, between Lakes Temagami and Temiscaming.

23. Biotite epidote gneiss conglomerate. Three-quarters of a mile N. W. of Copper Cliff mine.

27. Metamorphosed greywacke conglomerate. 200 yards S. E. of Copper Cliff mine.

26. Biotite gneiss. Railway track, one mile south of Stobie mine.

30. Sericite chlorite gneiss. Smelting furnace, Copper Cliff mine.

IV.—Rocks with no Indications of Clastic Origin.

No. 2. Granite (with allanite?) West side of largest island in west bay of Lake Wahnapitæ. (In contact with No. 1.)

3. Granite. Same as last.

4. Granite. Same as last.

11. Coarse granite. One mile south of Crow's Nest Rock, west side of Lake Temiscaming.

31. Fine hornblende biotite granite. Ridge three-quarters of a mile west of Stobie mine

No. 45. Crushed granite. Canadian Pacific Railway line, half a mile S. E. of Murray mine.
34. Garnet augite gneiss. West town-line of Hyman, two and a-half miles north of Spanish River.
44. Garnetiferous hornblende schist. Vermilion mine, one-third of a mile S. W. of the boarding house.

V.—Undoubted Eruptives.

No. 5. Uralitic gabbro. Shaft of Copper Cliff mine.
10. Similar rock, much more altered. Wall rock of shaft No. 2, Vermilion mine.
10. Similar rock, still more altered. Wall rock of shaft No. 2, Vermilion Lake.
32. Fine-grained diorite (cf. No. 5.) Ridge west of Stobie mine,
40. Hornblende schist or amphibolite. Murray mine.
35 & 42. Vitrophyre tuff. Lowest High Fall of the Onaping River.
46. Quartz-hypersthene gabbro. Dyke at Blezard mine.
48. Olivine diabase. Great dyke at foot of fifth portage, Spanish River.
49. Diabase (altered). Country rock of the Bruce mines.
39. Variolite. Ottawa Islet, Hudson Bay.
38. Diabase porphyrite. Nachvak, Labrador.
43. Hornblende pyroxenite (changing to talc). Nachvak, Labrador.
47. Micropegmatite. Eagle Rock Lake, Township of Levack.

Descriptions of the above Rocks.

No. 1. *Greywacke Conglomerate.*—West side of the largest island in West Bay, Lake Wahnapitæ. Well rounded granular quartz-felspar pebbles, two inches in diameter, cracked and scaled, imbedded in a fine compact black matrix. Section shows the pebbles to be made up of large felspar grains (mostly orthoclase) which are much broken and displaced. They further show indication of having been squeezed, in an undulatory extinction. These felspar grains are cemented by a recrystallized mosaic of chalcedonic quartz grains, which varies considerably in its fineness. It is well known that, under intense dynamic action, the quartz of a rock may be completely recrystallized into a mosaic of interlocking, fresh looking grains, while the felspar retains its original character and is only broken or optically disturbed. (cf. Rosenbusch, Mass. Gest., 2nd Ed., p. 41 ; Lehmann, Altkrystallinische Schiefergesteine, p. 250.)

The microscope shows the fine-grained matrix in which these pebbles are enclosed, to be composed of very minute sericite scales, which have resulted from the decomposition of felspar substance, together with extremely small quartz grains. This clay-like matrix contains numerous small angular fragments of quartz, orthoclase, and plagioclase. The structure of this rock is in every respect typically clastic, and it may be designated as a greywacke-conglomerate.

No. 2. *Granite.*—Same locality as No. 1. Rock of medium grain and somewhat porphyritic, through the presence of larger crystals of white orthoclase.

The section shows ordinary granitic quartz with fluid inclusions; orthoclase in large individuals, as well as in the finer-grained portion of the rock; plagioclase (oligoclase); and biotite, which is altered to chlorite, either wholly or in part. This section also contains a deep brown mineral, which is probably allanite. It is surrounded by a rim of epidote, as in the allanite-granites of Maryland. (cf. W. H. Hobbs: Am. Jour. Science (3) xxxviii, p. 223; and Tschermak's Min. and Petrog. Mitth. xi, p. 1, 1890). This rock shows the evidence of dynamic action to a slight degree, but has not the faintest indication of clastic origin.

No 3. *Granite.*—Same locality as Nos. 1 and 2. This rock is a granite like the last, except that it has a finer and more even grain, *i.e.*, is without porphyritic crystals.

The section shows under the microscope granitic quartz, orthoclase, plagioclase, biotite, with a little magnetite and pyrite. The biotite is much less altered than in the preceding specimen, showing only occasional chloritization in streaks. There is no allanite or epidote observable in this section.

No. 4. *Granite.* Same locality as Nos. 1, 2 and 3. The specimen is much darker and finer-grained than the last described rock, but the two varieties closely resemble one another.

The microscope shows granitic quartz, orthoclase extensively kaolinized, plagioclase, and biotite which is about half altered to chlorite. There is also some magnetite and pyrite.

This section is traversed by a narrow vein composed of quartz, orthoclase, plagioclase and chlorite. It is worthy of note that all the felspar of this vein presents a striking contrast to that of the rest of the rock in being quite clear and fresh. The place of the biotite of the granite is, however, here wholly taken by chlorite. There is also in this vein an extremely fibrous mineral in matted tufts. It is closely related to the chlorite and may be chrysotile or asbestus. The grain of this rock is fine; its structure is typically granitic.

No. 5. *Uralitic Gabbro or Gabbro Diorite*.—Shaft, Copper Cliff mine. Country-rock of the Copper Cliff copper-nickel pyrites.

A medium-grained massive greenstone or trap, containing both chalcopyrite and pyrrhotite. This rock is undoubtedly of eruptive origin, and from its present mineralogical composition it might be called a biotitic diorite. Both its hornblende and biotite are, however, of secondary origin, and have been derived from some pre-existing constituent which was in all probability pyroxene.

The microscope shows that the light portions of this section are composed of an interlacing network of idiomorphic felspar laths, whose fine striations show them to be plagioclase. The union of these felspar crystals to considerable irregular areas free from bisilicate prevents their producing a typical diabase or ophitic structure in the rock. The place of this felspar toward the more acid end of the plagioclase series is indicated by its local alteration to kaolin, rather than to calcite. Most of the felspar is penetrated by minute hornblende needles, and it is also often sprinkled with magnetite. Associated with the felspar are apatite needles, and a relatively small amount of quartz which fills up the interstices between the felspar laths.

The ferro-magnesian constituents of this rock (hornblende and biotite) are, like the felspar, grouped into aggregates which occupy irregular areas. The hornblende is dark green and strongly pleochroic. It occurs in clusters of small needles and grains which by their arrangement and structure bear every evidence of being secondary after pyroxene. The hornblende of the outside of these clusters is more compact and more darkly colored than that in their centre; and, while the remains of a pyroxene core could not in any case be definitely substantiated, the resemblance of this to other hornblende is too close to be mistaken. (cf. G. H. Williams: Gabbros and Associated Hornblende Rocks of Baltimore, Md., Bull. U.S.G.S., No. 28, Pl. I, Fig. 2, Pl. II, Fig. 1. Max Schuster: Neues Jahrbuch für Min., etc., Beil. Band V, p. 565.)

The biotite, which is less in amount than the hornblende, is of a copper red color and strongly pleochroic. It also bears strong indications of secondary origin. Both the hornblende and the biotite, but especially the latter, surround the ore (pyrite) in a way to suggest that the metamorphism to which they owe their origin, was in some way genetically connected with the deposit of the copper and nickel.

There can be little doubt that this rock was once an intrusive gabbro or diabase, which, owing to some subsequent metamorphism, has had its pyroxenic components changed to secondary hornblende or uralite. During the chemical and molecular changes which brought about the alteration, the felspar was filled with minute hornblende

needles, biotite was produced, and perhaps the copper and nickeliferous iron sulphides took their present form and position.

No. 6. *Microgranitic Rock* (possibly a recrystallized clastic arkose or greywacke).—One mile north-west of Sudbury. Appears to the unaided eye as a pale grey felsitic mass, without prominent grains or porphyritic crystals.

The microscope shows the slide to be composed of an evenly granular mosaic of quartz and felspar (orthoclase), interspersed with an abundance of biotite and considerable muscovite. Highly refractive epidote granules also occur and the biotite is rarely altered to chlorite. Traces of pyrite are also present.

The rock is not typically granitic, and yet it bears no certain evidence of clastic origin. The quartz and felspar grains interlock, and the biotite has evidently originated *in situ*. No outlines of originally clastic grains can be detected, though it is not impossible that this specimen may represent a metamorphosed and recrystallized clastic composed of granitic minerals.

No. 7. *Microgranitic Rock.*—300 yards east of Copper Cliff mine. A pinkish grey felsitic rock, much like the last described.

The microscope shows the structure of this rock to be much like that of the last described. Its composition is also similar, except that biotite is absent. Muscovite also is present in much smaller amount. The ferro-magnesian silicates are very sparsely distributed, and are mostly chlorite, with perhaps a trace of green hornblende. Epidote is present as in No. 6. The rock is mostly an even mosaic of quartz and felspar grains (orthoclase and microcline), the latter mineral being much more abundant that in No. 6. It is often stained with iron hydroxide which gives the pinkish tinge to the rock. The microscopical evidence of the genesis of this specimen is about the same as that obtained for the preceding (No. 6). The two succeeding specimens (8 and 9), although to the unaided eye apparently quite like the last two, are shown by the microscope to possess a typically clastic structure, which places their fragmental origin beyond all doubt.

No. 8. *Arkose Sandstone or Greywacke.*—Sturgeon River near junction of the Obabika. Pale greenish-grey fine grained rock of felsitic appearance.

The microscope at once disclosed the pronounced fragmental character of this rock, which is not so apparent to the unaided eye. Angular or slightly rounded grains of less than a millimetre average diameter, are imbedded in a fine felt-like matrix consisting principally of sericite (hydromica or kaolin). The angular grains are of the granitic minerals, quartz, orthoclase, microcline and oligoclase, with rarely a granule of reddish zircon. One fragment of well marked micropeg-

matite (granophyre) was also observed. The grains vary much in size and shape. Many of them are broken and their pieces only slightly dislocated. There is no mica in this rock, but there is a little chlorite, filling the narrower interstices between the grains.

The ground mass or cement of this rock is proportionately small in quantity. It is a confused mass of minute sericite scales, being the argillaceous product of decomposing felspar substance.

No. 9. *Coarser reddish Arkose.* East side of Maple Mountain, south of Montreal River. This specimen, upon a superficial examination, does not look unlike a rather fine-grained granite. It is, however, a clastic arkose sandstone like the last, but of somwhat coarser grain. The grains are mostly angular, and often much fractured. They consist of quartz, orthoclase and plagioclase. Neither mica nor chlorite occur in this section, except as a component of the sericite ground-mass or cement, which is here relatively more abundant than in the last-described specimen. Stains of ferric hydroxide are abundant and impart the reddish color to the rock.

No. 10. *Greatly altered Greenstone (Gabbro?)* —Shaft 2, Vermilion mine, Denison. The country-rock of the auriferous quartz vein.

A fine grained, evenly granular, greenish grey rock, with a somewhat silvery lustre.

The microscope shows this to be an extremely changed basic eruptive, probably originally a gabbro or a diabase. It appears to be a rock much like No. 5, but in a much more advanced stage of alteration. There is now no trace of its original structure nor of its original pyroxene. It is a confused aggregate of brown biotite, in rather sharp crystals, somewhat changed to chlorite, green hornblende fibres, epidote, quartz, calcite and sericite. The hornblende has, in all probability, resulted from the uralitization of pyroxene. The felspar of the original rock has also completely disappeared, and is now replaced by the micaceous mineral (sericite) and calcite. The quartz is all secondary, as is also the epidote and a little chlorite. In this confused mass are still numerous needles of apatite, which have survived all the alterations. Small grains of ilmenite, surrounded by leucoxene rims, are also present.

Rocks quite like this have been studied in many regions, where they can be traced with certainty into basic eruptives of normal character, and it is not impossible that specimens might be collected at this locality which would establish positively both the original form and the course of alteration of the present specimen.

No. 11. *Coarse-grained Granite.*—Lake Temiscaming, west side, one mile south of Crow's Nest Rock.

Macroscopically a coarse aggregate of grey quartz, reddish felspar and a pale yellowish alteration product.

The microscope shows a typically granitic structure, with orthoclase and microcline and a little striated plagioclase, and quartz. The rock is considerably altered, the felspar being opaque from this cause. The micaceous constituent, once present, has wholly disappeared, and is now replaced by a pale greenish-yellow sericite, containing iron in the form of magnetite. It also contains some sharp yellow needles (probably rutile). There has also been considerable potash mica (muscovite) developed at the expense of the orthoclase. There are further present in this granite as accessory constituents: zircon, in sharply defined reddish crystals; sphene, greatly altered: and a small amount of apatite.

No. 12. *Arkose Sandstone or Greywacke.*—South side Little River, Lake Temiscaming.

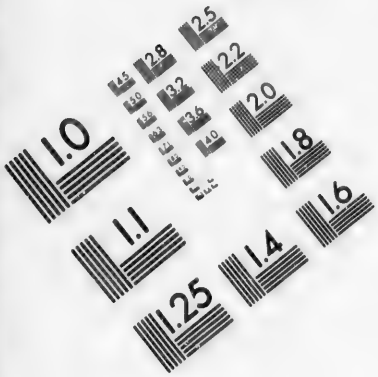
A dark grey, even and fine grained rock.

The microscope shows this to be composed of more or less rounded grains of granitic minerals—quartz, orthoclase, microcline and oligoclase—cemented by proportionately little sericite and chloritic material. The grains are all of the same average diameter, and plainly show by their character their derivation from granite while they appear to have suffered but little abrasion by running water. The dark color of this rock is largely due to the great amount of chlorite in its cement.

No. 13. *Quartzite Grit.*—High Pond, Maple Mountain, west of Lady Evelyn Lake and south of Montreal River.

This is a pale yellow rock, resembling a quartzite, but with distinct and more or less rounded, pebbles which in appearance closely resemble their matrix. Sericite is also abundantly visible to the unaided eye.

The miscroscope shows this rock to be composed of angular or but slightly rounded grains of granitic quartz, full of fluid inclusions, which are imbedded in a ground-mass of sericite and finer quartz fragments. These quartz grains or fragments differ greatly in size, but are under a millimeter in diameter. Felspar substance is now rare. It, however, was once present, but under the influence of dynamic action, it seems to have passed into sericite or muscovite. In a matrix of this character, medium sized pebbles are imbedded. These differ from the matrix principally in having a more silicious ground-mass, *i.e.*, they are freer from the sericite. They are, however, coated by a membrane of sericite, as is apt to be the case with squeezed conglomerates or grits. The rock shows distinct evidences of the action of pressure, and the development of its mica is probably due to this agency. A large fragment of the reddish zircon, like that in slides 8 and 11, was also observed in this section.



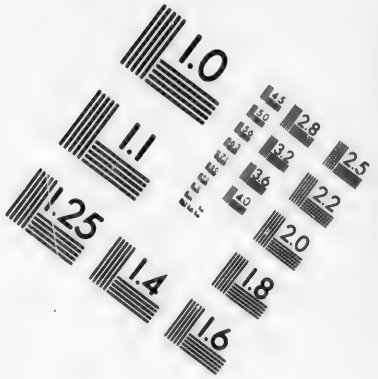
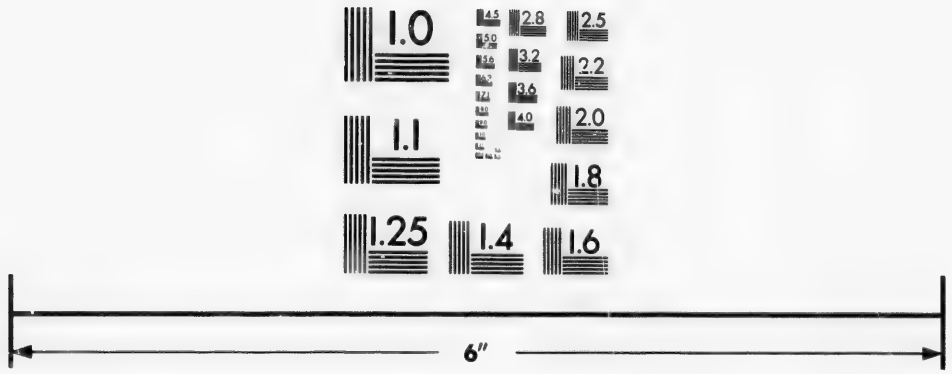
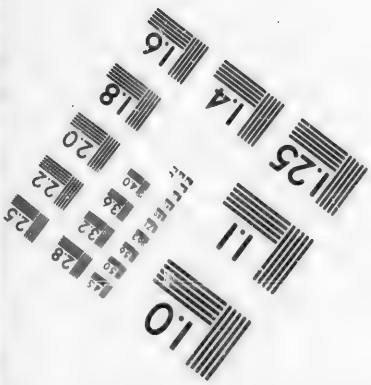
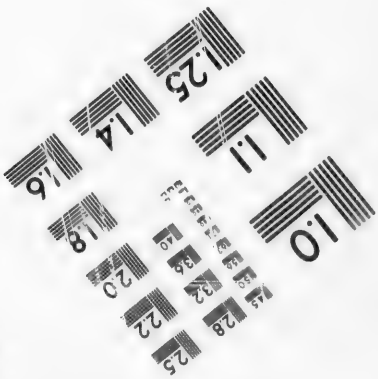


IMAGE EVALUATION TEST TARGET (MT-3)







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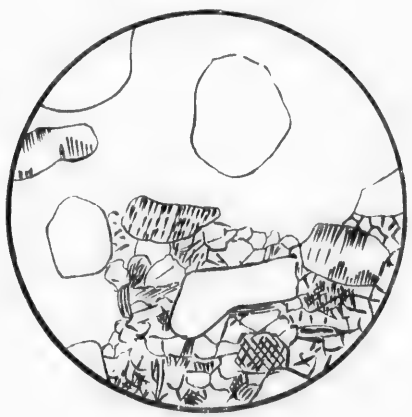
No. 14. *Greywacke.* 455½ miles west of Montreal, on the main line of the Canadian Pacific Railway.

A dark-bluish grey rock in which minute quartz fragments and grains are very apparent to the unaided eye.

Under the microscope numerous angular or somewhat rounded grains of granitic quartz of various sizes appear, imbedded in a finer aggregate of felspar, quartz, chlorite and mica. The dark color of the rock is due to minute dust-like inclusions of an opaque substance which crowd the felspar grains. They seem generally to be developed along cleavage cracks and appear to be of secondary origin, as they sometimes cover the whole felspar grain so as to make it almost opaque, and at other times are developed only in certain parts of the grain. The felspar substance is furthermore somewhat changed to mica and considerable chlorite is also developed. Reddish zicron and a little brown tourmaline are also found in this rock. The black opaque substance of this rock is not carbon, as it cannot be burned away by heating. It is some oxide of iron not easily dissolved by hydrochloric acid as is magnetite. By heating it is reddened, and may be ilmenite. See Figure 4.

FIGURE 4.



Section of specimen 14, from the main line of the Canadian Pacific Railway, 455½ miles west of Montreal. Greywacke, showing grains of quartz embedded in a finer aggregate of felspar, quartz, chlorite and mica.

No. 15. *Felsite or Microgranite.*—North side of Copper Cliff mine. A light colored evenly granular rock, containing very occasional black spots.

Under the microscope this is an aggregate of interlocking quartz and felspar grains with almost no trace of a ferro-magnesian constituent. Only minute needles and flakes of green hornblende are very sparsely disseminated, and these may make up the black spots visible in the hand specimen, though none of these were intersected by the thin section. The felspar is mostly orthoclase, with a little microcline and oligoclase. It is slightly kaolinized. Minute crystals of zircon are also rarely visible. There is nothing in the structure of this rock to indicate its clastic origin, although it is not impossible that it may be a recrystallized arkose. The constituents, especially the quartz, indicate by their undulatory extinction the action of pressure. (This rock may be compared with Nos. 2, 3 and 4.)

No. 16. *Microgranite or Felsite.*—South part of Lady Evelyn Lake. A fine compact pale grey rock, dotted with minute green specks.

The microscope shows this specimen to be an extremely even aggregrate of quartz and felspar grains, containing disseminated areas of chlorite. The separate grains are noticeable for having almost exactly the same shape and size throughout the rock ; still they form an interlocking mosaic and appear to have originated *in situ*. The felspar is mostly orthoclase, and the structure is typically that of a microgranite. No porphyritic crystals whatever are discernable. The ferro-magnesian silicate is wholly replaced by chlorite. It is not impossible that this rock may have been derived from the consolidation and recrystallization of an arkose. Its structure is not conclusive on this point.

No. 17. *White Sandstone.*—Log rollway, four miles north-east of inlet of Echo Lake.

This rock looks like a white and slightly felspathic quartzite, but its clastic character is apparent upon closer examination, even without the aid of the microscope.

The section of this specimen appears under the microscope to be a mass of variously shaped, but mostly rounded quartz grains. There is but very little true cement, but the quartz grains have undergone enlargement by the deposition of interstitial silica so that they frequently interlock by irregular sutures. This silica is optically continuous with the quartz grain which it surrounds, as described by Irving and Van Hise. (U. S. G. S., Bull. No. 8.) There is also some felspathic substance present in this rock which is considerably kaolinized. Rutile in deep yellow grains and crystals is also quite abundant, while the quartz encloses occasional zircon crystals.

No. 18. *Fine-grained Arkose or Greywacke.*—East side of Upper Wahnapitæ River, 13 miles north of mouth.

Compact, greenish-grey vitreous-looking rock, resembling a felsite.

The microscope shows small angular fragments of quartz with a little kaolinized felspar, distributed through an abundant sericite matrix. This has mostly resulted from the alteration of felspar substance, although it is mixed with some smaller quartz grains. The clastic origin of this rock is beyond a doubt.

No. 19. *Microgranite or Felsite.*—Foot of first portage below Rabbit Lake (between Lake Temagami and the foot of Lake Temiscaming.)

Compact brown felsitic rock.

The microscope shows this specimen to be comparable with No. 16 from Lady Evelyn Lake. It is an even grained mosaic of quartz and felspar ; the latter mineral (on account of the thickness of the section) being reddish and nearly opaque. The place of the ferro-magnesian constituent is now occupied by chlorite. Crystals of magnetite, which are sometimes accompanied by yellow rutile needles, occur near the chlorite. The shape of the grains in this specimen suggests, even more strongly than in the case of No. 16, a possible clastic origin.

No. 20. *Coarse conglomeratic Sandstone or Greywacke.*—Five miles north-east of inlet of Echo Lake.

Variagated rock of uneven coarse grain, containing good sized pebbles of white quartz.

The thin section of this specimen shows both rounded and angular quartz grains of very variable size imbedded in a moderately abundant sericitic matrix. Its appearance is closely like that of slide No. 9 from Maple Mountain. The quartz grains and pebbles exhibit the influence of pressure, many of them having an undulatory extinction and not infrequently being broken and displaced in the matrix.

No. 21. *Conglomerate (or Agglonerate?).*—Outlet of Lake Maskinongéwagaming.

Large rounded pebbles of a granular mottled rock in a black compact matrix.

The microscopic section of this specimen shows both kinds of rock and the contact-line between them. The pebbles are extremely altered, rather coarse grained diabase (dolerite). The structure of this rock is still sufficiently preserved to make its nature and origin certain, although its original mineral constituents are now entirely altered. Its lath-shaped felspar crystals have decomposed to a semi-opaque grey saussuritic mass, while its augite is now replaced by chlorite of a pale green color. Even its ilmenite has wholly disappeared, as such, but it has left an unmistakable record behind in the characteristic skeleton forms produced by the rhonbohedral parting, and now composed of dark grey leucoxene which has resulted from its alteration. Pyrite is also present in this altered diabase. The matrix of this rock is unmistakably clastic

in its character. Small angular and slightly rounded quartz grains with some felspar, are enclosed in a chloritic base, containing brightly polarizing sericite or kaolin.

No. 22. *Arkose Sandstone.*—Montreal River, four miles above Temagami Branch.

A reddish grey granular rock of medium even grain.

The microscope shows this to be an even grained mixture of somewhat rounded quartz grains with an equal amount of felspar (orthoclase, microcline and oligoclase). The minerals and their proportions are those of a granite, and yet the appearance of the grains and their relations to one another at once disclose the clastic character of the rock. The felspar, except a few of the largest grains, is quite changed to kaolin or sericite, although its external characters are still plainly discernable. This renders this specimen of peculiar interest in showing the origin of rocks like Nos. 9 and 20, whose sericitic matrix has, in all probability, passed through a similar stage in its development out of the felspar substance.

No. 23. *Biotite-epidote Gneiss (or Gneiss-conglomerate).*—Three quarters of a mile north-west of Copper Cliff mine.

This small specimen consists of two distinct portions: a dark, fine grained, micaceous rock, and a light felspathic one. The true relations of these two portions cannot be made out from the material at hand. The latter rock may be a nest or "eye" secretion such as are frequent in the gneissic rocks; or it may be a pebble. The extreme sharpness of the contact between the two portions points rather to the latter hypothesis.

As seen under the microscope, both portions of this specimen are gneisses. The darker portion, of which there is but very little in this section, is a fine grained aggregate, consisting mostly of biotite and epidote (or zoisite) with both felspar and quartz. The mica and epidote have certainly crystallized *in situ*, but they surround small transparent areas of quartz or felspar which look as though they might represent former fragments.

The lighter portion of the specimen is a felspathic gneiss, of uneven grain. It contains comparatively small amounts of the same biotite and epidote occurring in the darker portion, which have here also crystallized in their present position. No part of this rock now shows an undoubted clastic structure. If it was ever a sedimentary deposit, it has undergone very extensive recrystallization since its consolidation.

No. 24. *Banded coarse and fine conglomeratic Sandstone or Greywacke.*—South-west side of Bay Lake, Montreal River.

A portion of this specimen is quite like No. 20, but this alternates with much finer grained layers, which alone are represented in the thin section.

The section shows an aggregate of angular and subangular quartz grains with some felspar. Between these grains much chlorite has been developed, which, together with the magnetite present, gives the dark color to this layer.

No. 25. *Arkose Sandstone.*—North-east side of mountain, near Wendabin's house, Lady Evelyn Lake.

A reddish white rock of medium grain, which closely resembles a granite in macroscopic appearance.

Under the microscope the clastic nature of this rock is at once apparent, especially when it is viewed with a low power between crossed Nicol prisms. The grain varies considerably in its coarseness in different parts of the section. Quartz, orthoclase and plagioclase fragments are thickly crowded and connected by comparatively little sericitic matrix. This can, however, be seen to be forming at the expense of the felspar substance. There has been some enlargement of the grains by subsequent growth, so that, in spite of their clastic character, they often interlock with irregular sutures.

No. 26. *Dark fine-grained Biotite Gneiss.* (Extremely metamorphosed clastic).—Railway track, 1 mile south of the Stobie mine.

A dark-colored compact rock, which gives in the hand specimen but little clue to its true character.

Under the microscope this rock appears as a fine-grained mixture of biotite and quartz, to which a small proportion of felspar is added. The mica has evidently crystallized *in situ*, and exhibits a decided parallelism in the position of its flakes. This produces a somewhat indistinct gneissic structure, which is hardly observable at all in the hand specimen. Moreover, the mica is not evenly distributed through the rock, but is concentrated in bands which surround oval or lenticular areas. These are always elongated in the direction of gneissic structure and are composed of quartz, with occasionally a little felspar. The material which composes these elongated areas differs extremely in the coarseness of its grain, and appears to have been entirely recrystallized, although the form and distribution of the areas strongly suggest their being former pebbles. The only other constituent observed in this specimen consists of minute highly refractive granules surrounding grains of iron ore. They are the variety of sphene known as leucoxene.

My interpretation of this rock is that it was once a clastic greywacke, like many of the others represented in this collection, but that

it has subsequently undergone such complete metamorphism that a large amount of biotite was developed anew in it, while most of the quartz was recrystallized. These extensive changes have, however, gone on without entirely obliterating the original clastic structure of the rock.

No. 27. *Metamorphosed Greywacke Conglomerate.*—Two hundred yards east of Copper Cliff mine.

This is a pale pinkish, felsitic rock in which large and small irregularly shaped pebbles are very faintly traceable in a matrix that differs from them in external appearance only in being slightly darker.

The contrast between pebbles and matrix is much stronger under the microscope than it is in the hand specimen. The former (the pebbles) are composed of a granular aggregate of quartz and felspar, the latter being in proportionately small amount; while the matrix consists mostly of quartz and epidote. The latter mineral is in very minute highly refractive granules which are crowded into a nearly opaque mass until they are resolved by a high magnifying power. This epidote has originated in its present position as a result of metamorphism. The pebbles themselves also show the effect of metamorphism by dynamic action, being pressed and distorted in shape, as well as frequently broken and their fragments more or less displaced.

No. 28. *Felspathic Sandstone or Quartzite with large quartz pebbles(?).*—Lake Wahnapitæ Gold mine.

A vitreous white quartzite full of reddish felspar grains and containing large areas of pure white quartz, whose nature cannot be made out from this specimen.

The section, which is from the finer grained portion of this rock, shows under the microscope an appearance like that of No. 22. Angular or sub-angular quartz grains that have undergone some secondary enlargement, are mingled with felspar which is changing, though it has not yet entirely changed to a sericitic ground-mass.

No. 29. *A dark greenish-grey cryptocrystalline rock.*—Island in Lady Evelyn Lake.

This is a light colored felspathic sandstone, with an abundant sericitic-ground mass or matrix, much like the last described specimen, except that there has been no enlargement of the quartz grains to speak of.

No. 30. *Sericitic Chlorite Schist.*—The smelter, Copper Cliff mine near Sudbury.

A dark grey compact rock with small whitish blotches, and a quite distinct cleavage caused by the parallelism of the mica flakes.

This specimen, which was probably once a clastic, has undergone extreme metamorphism, whereby most of its original characters have

been obliterated. It is now a fine grained aggregate of quartz and sericite, with which is associated considerable pale green chlorite and a minute quantity of opaque iron oxide. The sericite and chlorite have a distinct parallelism in arrangement, producing a cleavage. Within this uniform mass, which makes up by far the larger portion of the section, are irregular and ill-defined areas much richer in quartz. These correspond to the lighter colored blotches in the specimen and may represent former pebbles which have been recrystallized and well nigh obliterated by the metamorphism. A small vein of quartz passes two-thirds of the way across the section and terminates within it. The indications are that the chlorite of this rock has been derived from biotite, and its sericite from felspar, although neither of these original constituents is now present.

No. 31. *Fine-grained Hornblende Biotite Granite.*—Ridge three quarters of a mile west of Stobie mine.

It is of course impossible for me to tell whether this rock may not possess in the field a parallel structure which would entitle it to be called a gneiss, but as far as this small specimen is concerned its structure is typically granitic.†

The constituents of this rock are quartz, orthoclase, microcline, oligoclase, biotite, hornblende, zircon, magnetite and epidote. The structure of this rock is typically granitic, but it shows a decided evidence of the action of pressure both in the disturbed optical behavior of the felspar, and in the peripheral granulation (Germ. Randliche Kataklase) produced by a rubbing of the grains against each other. (cf. Rosenbusch: Mass. Gest. 2nd. Ed., p. 42.) The ferro-magnesian components are not evenly distributed through the rock, but are aggregated in groups which consist mostly of hornblende and biotite, along with considerable reddish zircon. There is also scattered generally through the rock a small quantity of biotite. The latter mineral is of secondary origin. The opaque iron oxide of this rock resembles magnetite, but it is probably titaniferous, as each grain is surrounded by a highly refractive transparent border, which has all the properties of leucoxene (titanite).

No. 32. *Fine-grained Diorite.*—Country-rock of the ridge just west of Stobie mine.

A fine-grained dark hornblendic rock, without any foliation visible in the small hand specimen.

The microscope shows this rock to be a fine evenly granular aggregate of felspar, hornblende, biotite and magnetite, which is practically

† No indication of foliation was observed at this locality. The rock is extensively exposed and is all massive.—R. Bell.

free from quartz. The felspar is for the most part unstriated (which indicates, but does not prove, that it is orthoclase). If analysis should show that orthoclase were much the more abundant felspar, the rock would be more properly termed a syenite. The general character of the rock is, however, rather that of a diorite. Hornblende of the usual green variety, rarely with well-defined crystal form, is abundant. Associated with this is considerable biotite. The opaque iron oxide is surrounded by leucoxene borders. Apatite needles abound in the felspar, and quartz is only sporadically present. The structure of the rock, as seen in the section, is granular, and it is not impossible that it may have originated from the metamorphism of a basic eruptive containing pyroxene, although no trace of this mineral is now present. The specimen in comparable with No. 5 (the rock immediately associated in the ore of the Copper Cliff mine) without, however, there being here the certain proof of derivation that there exists.

No. 33. *Recrystallized Sandstone.*—The Hill, Sudbury Village.

A light grey, distinctly clastic though fine-grained rock. It has no pronounced cleavage in the hand specimen, but is somewhat evenly jointed.

The microscope shows this to be a fragmental rock composed mainly of quartz, in which considerable recrystallization has gone on. Good sized and quite irregularly shaped quartz grains are imbedded in a fine-grained mass, which also consists in large part of quartz mingled with some felspar substance. The quartz frequently shows the optical disturbance which is indicative of the action of pressure, and the interlocking of the grains proves that there has been considerable growth or enlargement since deposition. Chlorite has been extensively developed in the matrix of this rock. The only other minerals noticed were magnetite in minute specks and an occasional grain of zircon. A quartz vein of small dimensions crosses the thin section.

No. 34. *Garnetiferous Hornblende Biotite "Augen" Gneiss.*—West line of the township of Hyman, one mile north of Spanish River.

This is a normal gneiss, much "stretched," whose darker and finer grained portion bends around elongated lenses or "eyes," composed essentially of quartz. Minute crystals of red garnet are abundant, particularly around the edges of the quartz lenses.

The microscope shows the lenses or "eyes" of this specimen to be composed almost exclusively of large interlocking quartz grains, which bear witness by their undulatory extinction to the action of great pressure. The mass of the rock which encloses these lenticular areas is an aggregate of felspar (both orthoclase and plagioclase) quartz, biotite, hornblende, garnet, and iron oxide. The felspar, quartz and

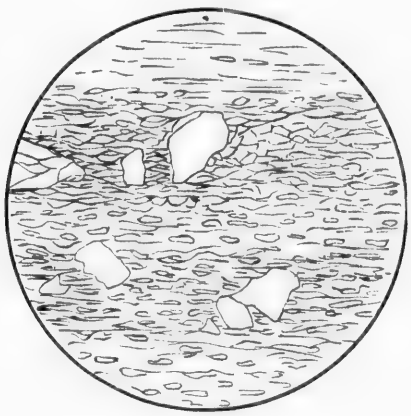
biotite present no peculiarities worthy of note. The hornblende is intensely trichroic, as follows: $\mathfrak{a}$ pale yellow; $\mathfrak{b}$ very dark yellowish-green; $\mathfrak{c}$ dark bluish-green; absorption: $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. It occurs in irregular patches or in prismatic crystalloids, associated with the biotite in matted aggregates. It has evidently originated *in situ*. The garnet is in good sized grains or imperfect dodecahedral crystals in the matrix of the rock. It also occurs in very minute, but very imperfect dodecahedrons in the quartz of the "eyes."

The structure of this rock is granular as far as its quartz and felspar are concerned, and shows the effect of pressure in the crushing of its grains. The interlacing or membranous (Germ., flaserig) structure characteristic of a gneiss is imparted altogether by the arrangement of its mica and hornblende. The recrystallization of all the components of this rock has been so complete that it can now only be spoken of as a gneiss. There is nothing in its structure to indicate whether it has been produced by dynamic metamorphism from a clastic arkose, from an eruptive granite, or whether it has always possessed the characters which it now exhibits.

No. 35. Same as No. 42., *q. v.*

No. 36. *Stretched Quartzite*—Three miles and a-half up the West Branch of Spanish River.

FIGURE 5.



Section of specimen 36, from three miles and a-half up the west branch of Spanish River. Stretched quartzite, showing the larger grains of quartz pulled apart in the direction of the stretching.

This is a pinkish to brownish, cryptocrystalline banded rock, which might be macroscopically designated as a banded jasper or felsite.

The microscope shows that it is a clastic, consisting of quartz which has been almost wholly recrystallized under the influence of intense pressure, and that it has thus had the parallel structure developed in it by an elongation of its grains in one direction, that is commonly known as "stretched" (Germ., gestreckte) structure.

During this recrystallization there has been a large amount of epidote developed in this rock, which appears as extremely minute granules. Felspar substance is also present in amounts which vary very much in different parts of the specimen, being most abundant in the pinkish bands. An occasional needle of hornblende may also be seen. That there has been an actual stretching of this rock during its recrystallization is proved by the fact that the larger quartz grains, which have retained their original individuality, have been broken and their fragments pulled apart, always in the direction of the banding. This may be seen from the accompanying sketch, Figure 5.

No. 37. *Extremely altered Gabbro or Diabase* (?)—Vermilion mine, shaft No. 2, Denison.

A pale grey compact even-grained rock, rich in pyrite.*

This rock now appears under the microscope as a confused mass of chlorite, biotite, epidote, sericite, quartz, pyrite, opaque iron oxide, leucoxene, calcite and apatite needles. All of these minerals except the apatite are of secondary origin, and with their production the original structure of the rock has been quite obliterated. This specimen is comparable with No. 10 from the same locality, of which it seems to represent a much more altered form.

It is of course impossible to say in such an altered rock what its original form was, but there is little doubt that it represents the remains of some basic eruptive (either diabase or gabbro). From analogy with Nos. 5 and 10 we may say that the choice is perhaps in favor of gabbro. The pyroxene of the original rock has given rise to the chlorite and biotite; the felspar, to the sericite, calcite and quartz. The iron oxide (ilmenite or titaniferous magnetite) is partly changed to sphene (leucoxene), while the apatite needles alone remain in their original form.

No. 38. Rock from Nachvak, Labrador. *See* end of list.

No. 39. Rock from Ottawa Islet, Hudson Bay. *See* end of list.

No. 40. *Amphibolite or Hornblende Schist.*—Murray mine.

A fine-grained very dark green or nearly black foliated rock, containing a much coarser felspathic or granitic vein.

This is a closely interwoven aggregate of green hornblende and brown biotite. The foliation is produced by the approximate parallel-

*The pyrite is thickly scattered through the rock in very fine grains.—R. B.

ism in the cleavage directions of these minerals. The only other constituents visible under the microscope are quartz, and ilmenite surrounded by veins of sphene (leucoxene). Of the origin of this rock we can say nothing now with certainty. It may well have resulted from the extreme metamorphism of some basic eruptive, but from a small specimen like this it is unsafe to draw any such conclusion. The felspathic vein is a much coarser aggregate of quartz, orthoclase and plagioclase with a little green hornblende. The felspar has many minute hornblende needles secondarily developed in it, but otherwise the rock appears like a fresh granite.

No. 41. *Recrystallized Arkose.*—Quarter of a mile north-west of Copper Cliff mine.

A grey rock enclosing large and small fragments of a highly felspathic granite or coarse gneiss.

The microscope shows plainly the clastic nature of this rock, in spite of the fact that extensive recrystallization has gone on in its matrix. This is a mixture of minute quartz and felspar grains, in which biotite and epidote have been extensively developed *in situ*. Some of the smaller areas included in this matrix seem to have been entirely recrystallized and now consist of an interlocking mosaic of limpid striated felspar (albite) and quartz grains. The largest fragments in this rock have, as far as can be determined by the microscope, the normal structure and composition of a hornblende-biotite granite.

Nos. 35 and 42. *Vitrophyre Tuff**.—Lowest falls of the Onaping River.

This dark compact rock is crowded with lighter-colored patches, which at first glance seem to resemble porphyritic crystals. A closer examination, however, shows that they possess extremely irregular outlines which are inconsistent with such an hypothesis.

Under the microscope the real character of this unusual rock is at once apparent. It consists of volcanic ejectamenta in the form of glass fragments of all shapes and sizes, associated with some crystals or crystal fragments (Fig 6). Some of the glass is, or was, a pumice, although most of it was compact, and exhibits in a beautiful manner the fluidal structure often observable in recent acid glasses. These sharply angular fragments grade down to those of microscopic dimensions, and all are imbedded in a dark matrix consisting of still finer fragments of a globulitic glass. This specimen is therefore a consolidated volcanic ash in which a great amount of chemical change (mainly silicification) has gone on without materially disguising the

* This rock has been mentioned by Prof. Bonney in his paper on the Sudbury rocks. (*l. c.* p. 40.)

original form of the rock. In spite of the rock having once been principally composed of glass it now contains none of this material. It has been replaced almost entirely by finely crystalline chalcedonic quartz. The cavities in the pumice have been filled with the same substance. Some of the crystals are rounded grains of limpid quartz without any impurity or composite character. In one of the specimens there is a large crystal of fresh felspar, presenting glistening cleavage surfaces, but this mineral is exceptional and does not appear in either of the thin sections.

In an appendix to a paper by Dr. Bell, read before the Geological Society of America, 31st December, 1890, the present writer says: "In a hand specimen this rock presents a nearly black felsitic matrix, in which are embedded sharply angular or slightly rounded fragments, varying from 1½ cm. in diameter downwards to ultra-microscopic dimensions. These fragments are lighter in color than the matrix, but differ considerably among themselves in their tint, structure and composition. The majority resemble chalcedony in appearance, others are greenish, while some of the largest fragments are now replaced by a single calcite individual. Occasional small grains of clear vitreous quartz may also be detected, while specks of magnetic pyrites (pyrrhotite) are everywhere abundant, Many of the angular fragments show distinctly under the lens a flow or vesicular structure, which is still more apparent in a thin section of the rock when seen under the microscope.

FIGURE 6.

Section of silicified Glass-Breccia or Vitrophyre Tuff. No. 42.

"The appearance of this rock when viewed with a low magnifying power (× 20 diameters) is shown in the accompanying figure 6, for which I am indebted to the skill of Mr. Charles R. Keyes, Fellow in Geology at the Johns Hopkins University.

"The fragments, even down to those of the smallest dimensions, have the angular form characteristic of glass sherds produced by explosive eruptions. The larger fragment in the lower part of the figure is finely vesicular, while the one above is more coarsely so. The flow structure is as perfectly marked by sinuous lines of globulites and microlites, which terminate abruptly against the broken edge of the glass particle, as in the most recent vitrophyre. Minute spots of opaque pyrrhotite are scattered throughout the section. The ground-mass is of a dark color, owing to the massing in it of minute black globulites, to whose nature the highest magnifying power gives no clue.

"Unfortunately, no* analysis of this interesting rock has as yet been made. Between crossed Nicols it is seen to be made up largely of chalcedonic quartz, which has changed the easily destructible glass into a sort of jasper. Chlorite is also abundant, frequently arranged as a border of radiating scales around the edges of the fragments, so as to coat them green in the hand specimen. The larger grains are always a fine mosaic of interlocking quartz, but some of the smaller ones are composed of a unit individual of clear vitreous quartz. The only other minerals which could be identified in the section are calcite and a few grains of a glassy, striated feldspar. The presence of this latter mineral is very noteworthy, as we should expect it to have disappeared during the vicissitudes through which this rock has passed.

"After a careful study of this rock I find it possible only to interpret it as a remarkable instance of a very ancient volcanic glass-breccia, preserved through the lucky accident of silicification. Nor did this process go on, as is usual, through devitrification and loss of structure, but rather like the gradual replacement of many silicified woods, whose every minute detail of structure is preserved. The rarity of such rocks in the earth's oldest formations is readily intelligible, but for this very reason the exceptional preservation of a rock like this is all the more welcome proof that explosive volcanic activity took place at the surface, then as now, and on a scale, if possible, even greater than that with which we are familiar."

No. 43. Rock from near Skynner's Cove, Nachvak, Labrador. *See* end of list.

*Since the above was written, Mr. Hoffmann has made an analysis of a specimen of this rock from the High Falls of Onaping River and found it to contain 60.23 per cent. of silica.

No. 44. *Garnetiferous Hornblende Schist.*—Vermilion mine. Roadside, one-third of a mile south-west of boarding house.

A fine-grained dark green hornblende schist, acting as the matrix for huge rounded crystals of reddish garnet, two inches or less in diameter.

The thin section of this specimen shows little except the garnet. This is quite normal, being reddish in color and isotropic in optical behavior. It is much cracked and slightly seamed with green chlorite which has resulted from its incipient alteration. It is also stained with iron hydroxide, and contains numerous inclusions of magnetite and quartz.

There is a very little of the hornblende schist also included in this section. It is an irregular aggregate of short and stout hornblende fibres mingled with more or less quartz.

No. 45. *Crushed and re-crystallized Granite.*—Canadian Pacific Railway, south-east of Murray mine.

Pale grey granitic rock.

This rock appears, under the microscope, like a granite which has been subjected to great crushing action. Its constituents are quartz, orthoclase, plagioclase, biotite, very little green hornblende, magnetite and zircon. The structure is irregular, the grains being of very unequal size with considerable fine mosaic. They, however, all interlock and appear to have been much broken by a crushing action. Many large felspar grains are fractured and the fragments separated. They are also granulated into a fine-grained mosaic around their edges. It is not possible to assert positively that this rock is not a wholly recrystallized arkose, composed of granitic debris, but there is now nothing in its composition or structure to indicate a clastic origin.

No. 46. *Quartz Hypersthene Gabbro with accessory Biotite.* Dyke, Dominion mine, township of Blezard.

A medium-grained massive brown trap, quite full of mica.

The microscope shows this to be an eruptive rock of quite exceptional character and interest. It belongs to the general type of gabbros, but has traces of a diabase-like structure in its long idiomorphic felspars; is related to the norites by the abundance of its hypersthene, and contains what is exceptional for all of these rock types—an abundance of original quartz. The rock is quite fresh, but shows the effect of dynamic action in the bending of felspar crystals and in the uralitization of the pyroxene.

The felspar is in stout lath-shaped crystals of good size, which produce a coarse ophitic or diabasic structure, as in many of the well known Scandinavian gabbros. They present a brownish color in the thin section, from an abundance of ultra-microscopic dust-like inclusions. They exhibit, in a beautiful manner, the effect of strain, in the bending

of the crystals and the production of secondary twinning lamellæ, similar to those described and figured by the writer from the Norites of the Cortlandt Series, near Peekskill, N. Y. (Am. Jour. Sci. (III) 33, p. 140, Feb., 1887.)

The pyroxene is both monoclinic (diallage) and orthorhombic (hypersthene) in about equal amounts. Both are undergoing alteration into compact green hornblende. The mica is an intensely pleochroic biotite. It is abundantly present in large flakes of irregular size and has all the properties of an original constituent. Quartz is also quite abundant in large clear grains of irregular shape, and was apparently the last mineral to crystallize. Apatite, zircon and magnetite are also present in considerable amount. This rock, although a typical gabbro, is unusually acid, and approaches in its quartz and zircon to the augite granites.

No. 47. *Granite (Micropegmatite).*—Eagle Rock Lake ("Moose Lake"), near west end ; township of Levack.

A dark rock of medium grain with reddish felspar.

The microscope shows this to be a biotite granite or granitite whose quartz and felspar are minutely intergrown as they are in graphic granite, thus producing the structure called micropegmatite or granophyre. This structure exists in this specimen in an unusual degree of perfection. It composes most of the rock-mass, and is usually developed as a delicate network surrounding and radiating from a central rectangular orthoclase crystal (generally a Carlsbad twin). The quartz exists for the most part intergrown with the felspar, but a few separate and individual grains may also be found. The ferro-magnesian silicate is biotite, now considerably altered. A little light green hornblende is also present, but this, like the chlorite, seems to be of secondary origin. Apatite is abundant in sharp acicular crystals, some of which have attained an extraordinary length.

No. 48. *Olivine Diabase.*—Great Dyke, 5th Portage, Spanish River.

A medium grained grey rock whose diabase structure is macroscopically apparent.

The microscope shows this specimen to be a fresh aggregate of olivine, reddish augite, plagioclase and ilmenite, with accessory apatite and biotite. Its diabase or ophitic structure is very typical. The olivine in this rock is remarkly fresh. It is in small pale yellow grains, which rarely show external crystal boundaries. It has a very high refractive index, no pleochroism, and contains glass inclusions. The augite is of the reddish and slightly pleochroic variety common in diabase. It not uncommonly shows zones of growth, having different shades of color. In form the augite is allotriomorphic, filling the interstices between the laths of plagioclase. The felspar (probably

labradorite) is idiomorphic and forms an interlacing network of lath-shaped crystals. It is the only constituent that shows any alteration, and this is comparatively slight. The opaque iron oxide is probably ilmenite. It is without distinctive form or alteration, and is sometimes surrounded by a narrow rim of biotite. Apatite is abundant.

No. 49. *Diabase.*—Bruce Mines, north shore of Lake Huron.

A dark brown granular rock, containing vein quartz and disseminated chalcopyrite.

The microscope shows this specimen to be a diabase, free from olivine and in rather an advanced stage of alteration. Its structure is quite normal. The stout and somewhat rounded laths of plagioclase are but little altered. The place of the pyroxene, on the other hand, is entirely taken by a granular aggregate of brownish crystalloids with a weak double refraction and high extinction. These may represent originally polysomatic augite (cf. Lawson, Rainy Lake Report), but they now occupy areas of the irregular form characteristic of diabase pyroxene. The common change of the pyroxene to hornblende or chlorite has hardly more than commenced in this rock. There is little secondary quartz present.

No. 50. *Felsite.*—Cliff on Colonization Road, half a mile north-west of Sudbury.

Pale grey compact felsite.

The microscope shows this rock to be a medium grained mosaic of interlocking quartz and felspar individuals, with which are associated a small amount of biotite, magnetite and minute highly refractive epidote (?) granules. All the constituents are quite fresh, although the felspar shows an incipient stage of kaolinization. The grain is not entirely even, nor are there any distinctly porphyritic crystals present. It is not impossible that the rock may be of clastic origin, but if it is, recrystallization has progressed so far as to obliterate all certain traces of its original structure.

No. 38. *Porphyritic Diabase or Diabase-Poryhyrite.*—(Dyke) Nachvak, Labrador.

A dark green compact and massive rock, in which minute crystals may be detected with the unaided eye. One side of this specimen represents the edge of the dyke, and from this the grain can be distinctly seen to grow coarser as we pass to the opposite side of the specimen.

The miscroscope shows that, in spite of considerable alteration, the original composition and structure of this rock are still plainly recognizable. Good sized lath-shaped crystals, of an almost colorless augite, are imbedded in a fine-grained but holocrystalline ground-mass, composed of minute lath-shaped felspars and green hornblende. The

only other noticeable constituent is titanic iron (ilmenite) in minute grains, which is largely altered to grey leucoxene.

The alteration to which this rock has been subjected, consists principally in uralitization of the pyroxene, *i.e.*, its change into more or less fibrous, secondary green hornblende. This change is only partial in the case of the larger porphyritic pyroxene crystals, so that a large core of unaltered mineral remains at the centre (Fig. 7). In the case

FIGURE 7.

Section of specimen 38, from a dyke at Nachvak, Labrador. Porphyritic diabase or diabase porphyrite, showing an unaltered core of pyroxene in a crystal which has been peripherally changed to hornblende.

of the finer pyroxene of the ground-mass, however, the change to hornblende has been complete. Accompanying this development of secondary hornblende, there has been some little biotite also formed. The felspar has itself suffered little alteration, although very delicate hornblende needles have also been developed in it. The opaque iron ore (ilmenite) is extremely changed to leucoxene, which surrounds it as a border, when the grain of the original mineral has not been entirely replaced. Twinning parallel to the orthopinacoid is a very common feature in the original augite of this rock.

No. 39. *Variolite* (*Spherulitic Diabase.*)—Ottawa Islet, Hudson Bay.

A compact greenish-grey rock, with round or oval spots of a paler color distributed somewhat irregularly through it.

The microscope shows this specimen to be, in spite of its greatly altered condition, a rock of unusual interest. It represents a peripheral facies of a diabase, called variolite (cf. Rosenbusch: Mass. Gest., 2nd Ed., p. 227), which, although well known from many localities in Europe, has not, as far as I am aware, ever yet been described from any part of America. This specimen came in all probability from near the edge of a mass of diabase, and was once a very fine grained (possibly partly glassy) and porphyritic variety of this rock. The round or oval spots represent former spherulites, which are characteristic of rocks

whose solidification has been rapid. Such spherulitic aggregations, while universally distributed through the acid rocks, are exceptional in those of basic composition. Nevertheless, they have been described from the edge of diabase areas in Bavaria, Saxony, Savoy, Piedmont, Russia and Great Britain.

This specimen of variolite from Hudson Bay has suffered total alteration of all its original mineral components, and yet enough of its original structure has been preserved to place its true character beyond reasonable doubt. The main mass of this rock is now a matted aggregate of secondary hornblende flakes and fibres, together with epidote, chlorite and a little quartz. There are, however, still recognizable traces of the former structure, for the narrow laths of felspar have frequently left their outlines where their substance has wholly disappeared. The outlines of the former porphyritic crystals are in the main quite sharp. From their shape they appear to have been largely olivine, although they are now all replaced by an aggregate of serpentine, chlorite and epidote. The oval patches of a lighter color appear in the thin section as cloudy and almost opaque areas. They are also composed largely of secondary hornblende, chlorite and epidote, but through them run the lighter, more or less radiating lines representing the former felspar crystals, whose arrangement is quite characteristic of the spherulites or "varioles" of the European varieties.

No. 43. *Hornblendic Pyroxenite*, in process of alteration to talc (steatite). Near Skynner's Cove, Nachvak, Labrador.

A dark massive rock of trappean aspect, but noticeably soft and easily scarred white by even a slight scratch.

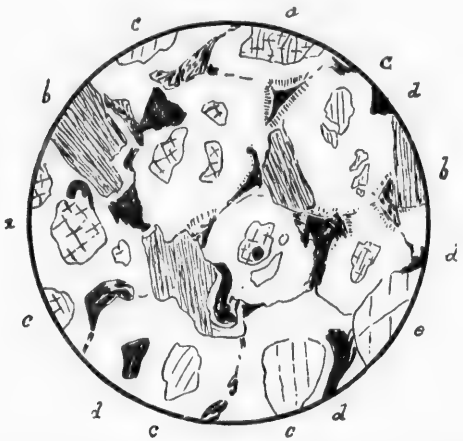
This specimen is of very exceptional interest, both on account of its original petrographical character, and also because of its alteration, the process of which is admirably shown in the thin section. The rock was once an evenly granular aggregate of enstatite, diallage, hornblende and magnetite.* The first named of these constituents is by far the most abundant and it has succumbed to an extensive alteration into a finely matted aggregate of talc scales. This same alteration has also gone on, although to a much less extent in the hornblende and also to a still smaller extent in the diallage (Fig. 8). It is analogous to the alteration of the enstatite from Bamle, Norway, to talc, so fully figured and described by vom Rath and Brögger (Monatsber. Berl. Akad. Wiss., Oct., 1876, and Zeitschrift. für Kryst. I. p. 18.)

The enstatite has very pale colors in the thin section, but has its characteristic pleochroism; **a**. reddish; **b**. yellowish to colorless; **c**.

* It is, therefore, a hornblendic variety of the rock-type for which the writer has suggested the name Websterite. Am. Geologist, July, 1890.

pale greenish. It also shows parallel extinction and all the other properties of an orthorhombic mineral, together with the rectangular cleavage of pyroxene in cross sections. It no longer has its original form, but now exists only as irregularly shaped cores in the midst of the talc which has taken its place.

FIGURE 8.



Section of specimen 43, from near Skynner's Cove, Nachvak, Labrador. Hornblendic pyroxenite in process of alteration to talc. *a*. Hypersthene or enstatite. *b*. Hornblende. *c*. Talc. *d*. Magnetite. *e*. Diallage.

The hornblende is next to the enstatite in abundance. It has all the properties of an original component. It is compact and with its usual optical orientation and pleochroism: $\mathfrak{a}$. and $\mathfrak{b}$. pale yellow; $\mathfrak{c}$. green. Its alteration to talc is as yet comparatively slight. The monoclinic pyroxene, recognized by its high extinctive angle, is nearly colorless and devoid of all pleochroism. Its amount is relatively small and it is the best preserved of all the constituents. The opaque iron ore in this rock occupies a very prominent place. It is in irregular grains, sometimes of rounded form, and is either compact or porous. The magnet shows it to be magnetite. The talc scales are usually arranged radially about these grains. The rounded contours of the largest and least solid of the magnetite areas, suggest that they may represent a replacement of olivine, but no certain traces of this mineral now exist in this rock.

APPENDIX II.

LEVELS OF LAKES ABOVE THE SEA.

The following are the approximate elevations above the sea, of the more important lakes shown on the map accompanying this report. In the case of lakes lying close to the Canadian Pacific Railway, the levels have been ascertained by direct comparison with some point on the line, but where the distance was considerable, the altitude of the lake was determined by barometric readings relatively to the railway, except, that of Onaping Lake, which was derived from a comparison of the mean of twelve barometric readings with the average reading at the sea level in the same month. The heights of the lakes in the north-eastern part of the sheet are deduced from the observations of the late Mr. Alex. Murray and myself, checked by the level of the railway at Wahnapitæ station. The names of the lakes are given in alphabetical order.

	Feet above sea level.
Bannerman Lake	1,270
Barlow (near W. end of Lake Nipissing)	650
Campbell do	645
Crooked or Crab (near Cartier Station)	1,348
Elbow (in Township 45)	678
Fairbank, or Washaigamog	867
Geneva	1,345
Koo-ka-gaming	879
Maskinongé-wagaming	890
Matta-gama-shing	866
Ma-zin-in-waning, or Vermilion	786
Murray (W. of Sturgeon River)	774
Nipissing	639
Ni-ta-wa-gami or Whitewater	835
Onaping	1,417
Onaping, Lower Lake	1,410
Panache	772
Pogamasing	1,181
Ramsay	820
Red Deer	685
Round	780
Straight	1,335
Vermilion, or Ma-zin-in-waning	786
Wahnapitæ	845
Washaigamog, or Fairbank	867
Wash-ki-gamog	788
White-water, or Ni-ta-wa-gami	835
Windy, or Ma-ko-ping	1,060

List of Elevations on the Canadian Pacific Railway from a point Fifty-two (52) miles west of Callander, which is 343·9 miles from Montreal.

These elevations were obtained from the profiles of the Canadian Pacific Railway corrected by comparison with the recently perfected levels of the United States lake surveys, as published by Mr. L. Y. Schermerhorn in the American Journal of Science, April, 1887, and the level of Lake Nipissing, as ascertained by William Murdoch, C.E., for the Department of Railways and Canals, Canada. The mean level of Lake Huron is given as $518\frac{3}{10}$ feet above mean sea level, while the level of Lake Nipissing, according to Mr. Murdoch, is 639 feet. Assuming these elevations as correct, the height of Sudbury Junction was fixed at 840 feet by the mean of the levels as brought up from Lakes Huron and Nipissing.

MAIN LINE CANADIAN PACIFIC RAILWAY.

Miles West of Callander.	Elevation above Sea.	Miles West of Callander.	Elevation above Sea.	Miles West of Callander.	Elevation above Sea.
52	653	87	784	120	960
53	655	88	812	121	996
54	657	89	812	122	1037
55	661	90	796	Onaping St.	1050
56	657	91	810	123	1075
57	657	Romford St.	835	124	1097
58	660	92	831	125	1145
59	671	93	853	126	1202
60	672	94	833	127	1219
61	675	95	838	128	1257
62	670	96	838	129	1292
63	668	97	882	130	1349
64	663	98	842	131	1360
65	664	Sudbury St.	840	132	1370
66	662	99	856	133	1351
67	662	100	906	Cartier St.	1356
68	662	101	954	134	1364
69	663	102	976	135	1345
70	665	Murray Mine.	975	136	1349
71	667	103	949	137	1359
72	670	104	895	138	1364
73	669	105	871	139	1343
74	670	106	875	140	1289
Markstay.	673	107	879	141	1258
Veuve River B'dge.	674	108	878	142	1261
75	693	109	881	143	1292
76	699	110	876	144	1340
77	714	Chelmsford St.	876	Straight Lake St.	1335
78	729	111	883	145	1336
79	740	112	877	146	1311
80	766	113	872	147	1259
81	823	114	865	148	1206
82	847	115	865	149	1202
83	847	116	858	150	1156
84	818	Bridge across Vermilion River.	858	151	1150
85	788	Larchwood St.	860	152	1145
86	777	117	867	153	1144
Wahnapitæ St.	776	118	884	Pogamasing St.	1144
Bridge across Wahnapitæ River.	776	119	931	154	1140
				155	1156

Sault Ste. Marie Branch.

Miles West of Sudbury.	Elevation above Sea.	Miles West of Sudbury.	Elevation above Sea.	Miles West of Sudbury.	Elevation above Sea.
Sudbury St.	840	17	777	35	690
1	834	18	794	36	646
2	829	Whitefish St.	791	37	620
3	828	19	785	Bridge across Spanish River.	620
Copper Cliff St.	832	20	810	38	671
4	836	21	822	39	677
5	848	22	803	40	671
6	857	23	795	Stanley St.	669
7	848	24	761	41	669
8	843	Worthington St.	756	42	663
9	792	25	756	43	663
10	783	26	738	44	682
11	786	27	710	45	667
Naughton St.	786	28	685	46	679
12	779	29	705	47	666
13	787	30	671	48	642
14	775	31	700	Webbwood St.	643
15	765	32	718	49	622
16	770	Nelson St.	702	50	646
Bridge across Vermilion River.	771	33	705		
		34	704		

APPENDIX III.

REPORT BY H. H. LYMAN, M.A., OF MONTREAL, ON LEPIDOPTERA COLLECTED BY DR. R. BELL IN THE COUNTRY NORTHWARD OF LAKE HURON.

These specimens were taken in different years by Dr. Bell and embrace seventy-three (73) species of the order. Most of them were unfortunately in poor condition, and hence several species could not be determined with certainty, while some of the specimens were quite undeterminable. Having been collected for the purpose of identification only, few of them were preserved in such a way as to be of value for museum purposes.

The species of most interest is *Cœnonympha Inornata*, Edw., described from the neighbourhood of Lake Winnipeg. This species was not previously known from so far east except that Mr. Wm. H. Edwards, from drawings by Gosse, believes that it occurs in Newfoundland. The form represented in this collection is a very dark one and was thought by Mr. Henry Edwards of New York, to be a new species, but Mr. W. H. Edwards, of Coalburgh, W. Va., pronounced it to be *Inornata*. The other species represented are chiefly those which might naturally be looked for in the Lake Huron region. One of them, however, *Thecla strigosa*, Harris, was not before known to occur so far north in this longitude, though, further west, it is said to have been taken as far north as Manitoba. One of the most interesting specimens is a hermaphrodite of *Argynnis Atlantis*, Edw., in which the right side is male and the left female. The abdomen is unfortunately in too poor a condition to admit of an examination of the genital organs.

For the determination of some of the specimens I am indebted to Mr. Wm. H. Edwards, Professor J. B. Smith, of New Jersey, and the Reverend Geo. D. Hulst, of Brooklyn, N.Y. The following is a list of the species with the localities and the dates of capture. The number of specimens taken at each place is indicated by the numbers in brackets. Where no number is given, one is to be understood.

Pieris Protodice, Bd.—Lec. Sault Ste. Marie, July 16th.

P. Oleracea, Harris. Sault Ste. Marie, La Cloche, Montreal River. June, July and August.

P. Rapæ, Linn. Lake Temiscaming. September.

Colias Philodice, Godt. Sault Ste. Marie, Lake Temagami, Lake Temiscaming, La Cloche, Sudbury. July, August and September.

C. Interior, Scudder. (4) Spanish River, Lake Temagami. August.
Danais Archippus, Fab. Georgian Bay. July.
Argynnis Cybele, Fab. (3) Georgian Bay, La Cloche. July and August.
A. Aphrodite, Fab. (3) Lake Temiscaming, (3) Spanish River, Montreal River. July and August.
A. Atlantis, Edw. Sault Ste. Marie. June, July and August. One specimen is a hermaphrodite.
A. Myrina, Cram. (4) Sault Ste. Marie. July and August.
A. Charicles, Schneid. (4) Spanish River. July.
A. Bellona, Fab. Lake Temiscaming. July.
Phyciodes Nycteis, Doub.–Hew. (2). Sault Ste. Marie. July.
P. Tharos, Drury. (8) Sault Ste. Marie, Spanish River. July.
Grapta Faunus, Edw. Montreal River. (2) Lake Temagami. (4) Vermilion River. August and September.
G. Progne, Cram. Vermilion Lake. July.
Vanessa Antiopa, Linn. (2) Lake Temagami, Vermilion River. August and September.
Vanessa J. Album, Bd.–Lec. Lake Temagami. (3) Vermilion River. (4) Echo Lake (2) Montreal River. July, August and September.
V. Milberti, Godt. (3) Sault St. Marie. July.
Pyrameis Atalanta, Linn. (2) Sault Ste. Marie, July.
P. Cardui, Linn. (2) Sault Ste. Marit. July.
P. Huntera, Fab. Sault Ste. Marie. July.
Limenitis Arthemis, Drury. (2) Lake Temiscaming. July. (2) Sault Ste. Marie. June and July.
Neonympha Canthus, Bd.–Lec. Sault Ste. Marie. July.
Cœnonympha Inornata, Edw. (4) Sault Ste. Marie. June 28th, July 8th.
Satyrus Nephele, Kirby. Georgian Bay. (2) La Cloche. August.
Thecla Strigosa, Harris. Wahnapitæ Lake. August 17th.
Chrysophanus Thoe, Bd.–Lec. Sault Ste. Marie. July.
C. Hypophleas, Bd. (2) Lake Temiscaming. Little Current. (3) Sault Ste. Marie. July, August and September.
Lycæna ——? Sp. undeterminable. Sault Ste. Marie. June 28th.
Pamphila Peckius, Kirby. Sault Ste. Marie. June.
Pamphila——? Sp. undeterminable. Sault Ste. Marie. End of August.
P. Mystic, Edw. (2) Sault Ste. Marie. June and July.
P. Cerues, Bd.–Lec. (2) Sault Ste. Marie. July.
Nisoniades——? Sp. undeterminable. La Cloche. August.
Deilephila Lineata, F. (2) Michipicoten. August.

Ctenucha Virginica, Charp. Sault Ste. Marie. June 30th.
Lithosia Bicolor, Grote. Wannapitæ River. August 16th.
Euphanessa Mendica, Walk. (2) Sault Ste. Marie. July.
Crocota——? Mattawa. July 14th.
C. Rubicundaria, Hubn. Sault Ste. Marie. July.
Arctia Saundersii, Grote. Georgian Bay. August.
A. Phyllira, Drury. Near Bruce Mines. August 6th.
Agrotis Normaniana, Grote. Mattawa, July.
A. Haruspica, Grote. Mattawa. July 14th.
A. Ypsilon, Rott. Sault Ste. Marie. July.
A. Saucia, Hubn. Sault Ste. Marie. June 14th.
Mamestra Vicina, Grote. Mattawa. July.
Scoliopteryx Libatrix, Linn. Lake Temiscaming. July.
Lithophane Pexata, Grote. Upper Ottawa River, September.
Aletia Argillacea, Hubn. (5) Upper Ottawa River. September.
Plusia Balluca, Gey. Mattawa. July.
P. Bimaculata, Steph. (2) Lake Temiscaming. July.
P. Mortuorum, Guen. (2) Montreal River. August 2nd.
P. Viridisignata, Grote. Montreal River, August 9th.
Heliothis Armiger, Hubn. Vermilion River. September.
Catocala Concumbens, Walk. Sault Ste. Marie. August.
Pseudaglossa Lubricalis, Gey. Mattawa. July 14th.
Epizeuxis Æmula, Hubn. Vermilion River. August.
E. Americalis, Guen. Mattawa. July.
Eutrapela Transversata, Drury. Montreal River and Trout River to the north of it. August.
E. Transversata, Drury, Var. Vermilion River. September.
Therina Fervidaria, Hubn. (2) Montreal River. August 9th.
Sicya Macularia, Harris. La Cloche. July.
Angerona Crocataria, Fab. Sault Ste. Marie. July.
Corycia Vestaliata, Guen. Sault Ste. Marie. July 2nd.
C. Semiclarata, Walk. Sault Ste. Marie. June 30th.
Semiothisa Granitata, Guen. Vermilion River. August.
Cleora Pulchraria, Minot. Montreal River, August 9th; (2) Onaping Lake, September 11th.
Triphosa Dubitata, Steph. Near Onaping Lake, September Township of Levack, October.
Rheumaptera Unangulata, Haw. Sault Ste. Marie. July.
R. Hastata, Linn. (2) Sault Ste. Marie. July.
Hydriomena Sordidata, Fab. Var. *Glaucata*, Pack. Sault Ste. Marie. July.
Salebria Fusca, Haw. Sault Ste. Marie. July.

APPENDIX IV.

MEANINGS OF INDIAN GEOGRAPHICAL NAMES IN THE COUNTRY AROUND SUDBURY.

During the progress of our surveys and explorations, care was taken to obain from the local Indians the meanings of their geographical names as far as they were able to give them. My own knowledge of the Ojibwé or Otchipwai language enabled me to verify these in most cases. But all the translations in the following list have been submitted to Mr. Robert Ross, of Naughton, and Professor John Galbraith, C.E., of Toronto, both of whom have a knowledge of this language. Some of these names have the Cree rather than the Ojibwé form, from which it appears probable that the Crees, who now inhabit the country around James' Bay, may have at one time extended further south. The meanings of these Indian names are often obscured by contractions, which are very common in the Ojibwé dialect, and also by corruptions that have crept in by carelessness and have been adopted by the Indians themselves. The spelling in common use is given with the addition, in some cases, of what is believed to be the correct form. In the pronunciation, it is to be understood that the value of the letters is the same as in French, which gives the sound much more correctly than by using the English pronunciation. Most of the Indian geographical names are in the locative form, so that *at* or *the place of* is to be understood in addition to the interpretation given in this list. The names are in alphabetical order.

Ashigan-ipoon-sap-agaming—The lake where nets are set for bass in winter.—A lake just south of Koo-ka-gaming Lake.

Ka-bi (or pi)-to-ti-twi-a—The stream having the same course as (or continuing the course of) another stream; or it might, in other cases, mean the stream parallel to another stream.—A branch of Sturgeon River from the west in townships 25 and 23, which has the same course as the stretch of the latter just below it.

Ka-kake-shi-wish-ta-gwa-ning—The cormorant's head.—A rock forming part of the cliffs on the west side of Onaping Lake, a short distance north of Proudfoot's line.

Ka-min-i-tik-wia-kwuk—River having many islands.—A stream in the township of Morgan.

Ka-si-sé-gan-da-ga-wonk—Where there are spruces.—A lake west of upper Vermilion River and near Proudfoot's east-and-west line.

Ka-wa-wi-ai-gama—The round lake.—Situated east of the outlet of Onaping Lake.

Ka-wa-sa-ski (or hi)-gama—The lake of bays.—A lake on a small river of the same name which flows into the upper Vermilion from the west.

Ka-wak-won-é-ka-gama—Lake where *tripe de roche* is plentiful.—Situated a short distance west of Upper Vermilion River.

Kin-ni-wabik—(Golden) eagle's rock.—A lake in the south-eastern part of Levack, which the surveyors have called "Moose Lake."

Kitchi-mish-kwis—Big grass.—A branch of Vermilion River from the north.

Kino-gami—Long lake.—Between Lake Panache and Wahnapitæ Station on the Canadian Pacific Railway.

Koo-ka-gaming—Owl lake.—A lake nine miles long, situated a short distance east of Wahnapitæ Lake.

Ma-ko-ping—Contraction for bear lake—literally, bear's water.—The aboriginal name for the sheet of water which has been re-named "Windy Lake," on the line of the Canadian Pacific Railway north-west of Sudbury.

Mat-ta-ga-ma-shing—A contraction for Mat-ta-wa-ga-ma-shing—The meeting of the waters—literally, the place where the lakes meet together.—At this sheet of water two arms meet and into each of them a canoe-route falls. A lake laying just east of Wahnapitæ Lake.

Maskin-ongé-wa-gaming—Big pike lake.—Between Sturgeon River and Wahnapitæ Lake.

Maz-in-in-waning—The pictured water.—So called from the reflection of the landscape on the calm water in the summer evenings. Situated in the township of Fairbank. The surveyors re-named it "Vermilion Lake."

Ministik (Sa-kuh-i-kun)—Island lake (Cree).—A lake on the town-line between Ermatinger and Cascaden.

Miska-wi-ko-bang—Place of the rushes.—A lake about ten miles north of the township of Lumsden.

Muck-a-tai-wa-gaming—Black lake.—On the east side of the Whitefish Indian reserve.

Na-mai-gus (or goos)—Trout (the large grey or lake trout).—A lake east of Onaping River.

Ni-nips-ka-gaming (or Ni-bish-i-ka-gaming)—Leafy lake—The source of Vermilion River.—Situated a short distance east of Onaping Lake.

Nipissing—A contraction for A-nib (or nip)-i-sing—The place of elms. Or, possibly, it may mean the little lake—as compared with Lake Huron.—Lake at the head of French River.

Nita-wa-gami—Lake where the stream is born—A lake in the northern part of Snider. Re-named Whitewater Lake by the surveyors.

O-na-ping.—May be a contraction for O (or wun)-num-un-a-ning—Cree for red paint or "vermilion" place. Perhaps the reason why the river from the junction of this stream with what the Indians call the Onwatin, has received the name of Vermilion River, is to be traced to this meaning. Onaping might also be a contraction for Oo-na-min-a-ping—place of gooseberries, Oo-na-min being the word for the fruit we call gooseberries in the dialect of the Crees around James' Bay, although shabomin is the name of these berries in the Ojibwé dialect.

On-wa-tin—Calm or smooth—literally no wind.—A lake on the Vermilion River, regarded by the Indians as the source of the main river, which is known among them by the same name.

Pawa-tik, or Pow-a-tik—Rapid.—A small river which flows through township 66.

Pay-pun-aka-mas-kik—Probably a contraction for Pay-i-pa-pun-aka-mas-kik. Where the sun shines out upon the other side, or there is a glint of sunshine over on the other side of the water.—A lake between the Onaping and upper Vermilion River. Its northern extremity touches Proudfoot's east-and-west line.

Pi-mitchi-wan-ga (or ka)—Probably for Pi-midgi-i-wan-ka—Place of running water.—A lake on the upper Vermilion River.

Ping-wi-i-min-ka-ni-wi (sipi)—Sand-cherry river with the two branches.—A small river flowing into the township of Morgan.

Po (or pa)-gama-sing—A contraction for either Opa-gama-sing, Lake-of-the-narrows or Pa-gwa-gama-sing, shallow lake. Lake of the Shallow Norrows would be an appropriate name.—A lake ten miles long, situated just west of Spanish River, opposite the station of the same name on the Canadian Pacific Railway.

Sa-ga-mook—The Peninsula.—The name of an Indian village situated at a peninsula on the north shore of Lake Huron a few miles west of La Cloche.

Sagitchi-wai-a-ga-mog—Lake with the hills where the water goes out. Sagitchi is a single particle and means out of, or out from, and wai is a contraction for wai-tchu, a hill.—A lake situated just north of the township of Lumsden.

Schkow-a-na-ning (for Wa-ska-wa-naning).—The place of the turn (in the canoe-route). A lake east of Onaping River.

Shi-ba-o-na-ning—The channel.—The original and proper name of a place on the north shore of Lake Huron. Called also "Killarney."

Shing-wak—White pine.—A lake a short distance east of Onaping River.

Temagami—Deep lake (in the Ojibwé or Otchipwai dialect).—A lake thirty miles long between the Montreal and Sturgeon Rivers and sending a stream into each.

Temiscaming—Deep lake (in the Cree dialect).—On the Ottawa River, where it changes its general course from west to east.

Wab-a-gi-(or ki)-zhik—Clear or white sky.—A lake in the southern part of Nairn.

Wah-na-pit-æ—More ocrrectly Wa-na-pit-é-(ping), the final syllable being merely locative, as it was formerly spelled upon the maps. The change to the present incorrect form was introduced by the late Mr. Alexander Murray when he surveyed the lake in 1856, and arose from a misapprehension of the proper pronunciation of the diphthong æ and which, moreover, does not occur at all in the Cree or Ojibwé language. The accent is on the final é. The h is the first syllable is unnecessary, as the a alone is sufficient, being always prounced soft and long in the Ojibwé language. A return to the proper and simpler spelling would be welcomed by everyone who has occasion to write this name often. The word means hollow (molar) tooth and was probably suggested to the Indians, who are good map-makers, by the fact that the outline of the lake resembles that of a side view of a molar tooth. It is the largest lake on the river of the same name.

Wa-na-tanga-(sa-gai-(hi)-gan)–Hollowed-rock lake.—Situated east of Onaping River and north of the township of Levack.

Was-ka-gaming, for Oja-wask-ka-gaming—Green or blue lake, these colours having only one adjective to denote them. Called Lake Panache, (Antler Lake) on the maps.

Wa-shai-ga-mog—Clear lake.—A lake in the south-west corner of the township of Fairbank. Re-named, contrary to the wishes of the natives, "Fairbank Lake." A similar name with the prefix ka belongs to a lake in township 66.

Was-ki-ga-mog—the lake that curves round.—A hook-shaped lake on the Maskinongé River, not far west of Sturgeon River.

We-quet-(sa-gai) (hi)-gan)—Bay lake.—In the township of Ermatinger.

Wenge-kis-i-naw—Why is it cold?—The name of an Indian, after whom a stream north-west of Morgan, and passing through his hunting ground, is called.

Wia-shai-ga-mog—Clear lake.—The same as Wa-sha-ga-mog.